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REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD
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MICROMEDIA

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIONAL APPLICATIONS FOR THE SYDNEY COALFIELD

Final Report
by

ASSOCIATED MINING CONSULTANTS LTD.

PERMIT TO PRACTICE
ASSOCIATED MINING CONSULTANTS LTD.
Signature Alan L. Craven
Date 31 March 1988
PERMIT NUMBER: P 2361
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

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March 24, 1988
File: PC04
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Department of Energy, Mines and Resources
CANMET, Coal Research Laboratory
210 George Street
SYDNEY, Nova Scotia
BIP IJ3

Attention: Mr. G.A. Haslett, P.Eng.
Scientific Authority

Dear Sirs:

Re: Remote and Automatic Control System for Longwall Mining. A Review Report on Potential Applications for the Sydney Coalfield DSS Contract Number 23440-7-9017/01-SQ

We take pleasure in submitting our final report on the remote and automatic control systems for longwall mining.

We would like to thank the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada for sponsoring the study and for their advice and guidance during its execution.

Respectfully submitted,

ASSOCIATED MINING CONSULTANTS LTD.

Alan L Craven,

Alan L. Craven
Manager

ALC/des/A-6

Enclosures

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

TABLE OF CONTENTS

EXECUTIVE SUMMARY

SOMMAIRE

ACKNOWLEDGEMENTS

1.0 INTRODUCTION

2.0 LONGWALL MINING SYSTEMS

3.0 ROOF SUPPORTS

4.0 SHEARERS AND PLOWS

5.0 ARMOURED FACE CONVEYORS

6.0 INTEGRATED SYSTEMS

7.0 BENEFITS

8.0 SYDNEY COALFIELD MINING OPERATIONS

9.0 APPLICATION TO THE SYDNEY COALFIELD

10.0 CONCLUSIONS AND RECOMMENDATIONS

11.0 SELECTED REFERENCES

APPENDIX A ROOF SUPPORT CONTROL SYSTEMS
APPENDIX B AUTOMATIC STEERING SYSTEMS
APPENDIX C DIGITAL RADIO CONTROL SYSTEM FOR SHEARERS
APPENDIX D APPARATUS FOR INFRARED CONTROL OF MINING MACHINES
APPENDIX E MULTI-PURPOSE AUTOMATIC CONTROL EQUIPMENT (MACE)
APPENDIX F PRINCE REMOTE MONITORING SYSTEM
APPENDIX G LINGAN REMOTE MONITORING SYSTEM

EXECUTIVE SUMMARY

An appraisal of remote and automatic control systems for longwall mining has been carried out following a world wide literature review and visits to manufacturers.

Mining engineers have recognized the need for these systems for some time as the potential benefits are:

- reduction in the cost of coal production;
- improved environmental conditions and increased safety;
- better machine availability and utilization;
- higher production rates.

It is a misconception, however, that indiscriminately applying remote and automatic control systems will instantly achieve these benefits. The technology must be applied as a total system. In existing mines, the staged introduction of individual systems is essential to allow management and workforce time to adapt to the new technology and to gain confidence in its reliability and benefits.

The world leaders in the manufacture of remote and automatic control systems applied to longwall mining are Western European; United Kingdom and West Germany. The research, development and trials of the systems are technically far in advance of other countries, but their systems are based on the specific mining conditions prevailing in their home coalfields. The applicability of each system must, therefore, be fully assessed for its application or adaptability to world wide markets.

Developments have been made in these areas. Automatic steering systems incorporating natural radiation sensors and transducers to overcome horizon, vertical and roll control have been widely used. The development of the recognition system using a steering algorithm and the pick force sensor for horizon control systems has catered to different applications in the world wide market and allowed full seam extraction.

The major development in powered supports has come through the use of electro hydraulic valve systems which allow greater ease of operation. The development of infra-red support initiation can remove the workforce from support setting and off the coal face itself.

Many mining problems arise due to misalignment of the face. The new supports with their faster setting cycles can alleviate face misalignment. Support manufacturers have developed transducers for support AFC rams, to ensure full push-over and alignment. Cord transducers can measure advance and supports can be backed by sophisticated monitoring and control systems using gate end computers with VDU's.

There are three areas where remote and automatic control systems require development, before automation can be fully achieved:

- cutting horizon (horizon control, vertical control);
- face alignment and support advance;
- machine tilt (roll control).

Development towards the automation of the coal face continues with:

- a standardized hardware package for monitoring equipment;
- full surface production monitoring systems;

- expert systems;
- more sophisticated transducers.

In the past five years, there has been substantial progress with the development of automatic and remote control systems for longwall faces in coal mines. This report presents an up-to-date review and assessment of these developments.

SOMMAIRE

Une évaluation des systèmes de réglage automatiques et par télécommande en usage dans les exploitations minières à longue taille a été faite à la suite d'une révision de la documentation internationale et de visites aux fabricants.

Depuis quelque temps déjà, les ingénieurs des mines se sont rendus compte qu'un besoin existe pour ce genre de systèmes dont les bénéfices possibles sont:

- une réduction du coût de production du charbon;
- un meilleur environnement et une plus grande sécurité;
- une meilleure disponibilité et un meilleur emploi des machines;
- un plus haut taux de production.

Cependant, ce serait une conception erronée de croire que la simple application de ces systèmes de réglage automatiques et par télécommande obtiendrait ces bénéfices. La technologie de ces systèmes doit être appliquée dans son ensemble. Dans les mines existant présentement, l'introduction étagée de systèmes individuels est nécessaire afin que la gestion et les travailleurs aient le temps de s'adapter à la nouvelle technologie et de s'assurer de ses bénéfices et de sa fiabilité.

Les plus importants fabricants internationaux de systèmes de réglage automatiques et par télécommande utilisables dans les exploitations minières à longue taille se trouvent en Europe occidentale soit au Royaume-Uni et en Allemagne de l'Ouest. La recherche , le développement et les essais de ces systèmes y sont techniquement plus avancés que dans d'autres pays mais leurs systèmes sont basés sur les conditions minières spécifiques et prédominantes à leurs propres chantiers miniers. Chaque système doit donc être évalué quant à son application et à son adaptabilité aux marchés mondiaux.

Avant de passer à l'automation complète, certains développements s'avèrent nécessaires, particulièrement dans les domaines suivants:

- niveaux d'abattage (circuits de réglage horizontal et vertical);
- alignement du front de taille et avancement des soutènements;
- inclinaison de la machine (circuit de réglage de roulement)

Plusieurs développements ont eu lieu en ces domaines. Des systèmes de pilotage automatiques comprenant des détecteurs de radiation naturelle et des transmetteurs contrôlant les circuits de réglage horizontal, vertical et de roulement ont été largement utilisés. Le développement du système de reconnaissance employant une système algorithme et un capteur d'effort de coupe de pic pour les circuits de réglage horizontal a abouti à différentes applications sur le marché international et a permis d'arriver à une extraction complète des couches.

Les principaux développements dans les soutènements mécanisés proviennent de l'emploi de systèmes de valves électro-hydrauliques qui facilitent l'opération. Le développement de soutènements à rayons infra-rouges permet de retirer la main-d'oeuvre de l'installation des soutènements et de la couche de charbon même.

Plusieurs problèmes miniers viennent du mauvais alignement de la taille. Les nouveaux soutènements avec leurs cycles d'installation rapide peuvent corriger le mauvais alignement de la taille. Les fabricants de soutènements ont développé des transmetteurs pour des soutènements à crin hydraulique (convoyeur blindé à raclettes) afin d'assurer un bon alignement. Les transmetteurs à corde peuvent mesurer l'avancement et les soutènements peuvent être renforcés par des systèmes sophistiqués de circuits de réglage et de surveillance utilisant des ordinateurs aux têtes de voie avec écrans de visualisation.

Le développement vers l'automatisation de la taille de charbon se poursuit avec:

- un matériel standardisé (hardware) pour l'équipement de surveillance;
- des systèmes de surveillance pour toute la production de surface;
- des systèmes spécialisés;
- des transmetteurs plus sophistiqués.

Durant les cinq dernières années, d'importants progrès ont été faits dans le développement des systèmes de réglage automatiques et par télécommande pour les exploitations charbonnières à longues tailles. Le présent rapport passe en revue et évalue ces développements.

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

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AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 1.0 - INTRODUCTION

TABLE OF CONTENTS

1.0 INTRODUCTION

.1 BACKGROUND
.2 SCOPE OF WORK
.3 STUDY EXECUTION

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

1.0 INTRODUCTION

1.1 BACKGROUND

Mechanization of longwall coal mining took a major step forward with the introduction of the Anderton Shearer loader in 1954, followed by the installation of the first powered supports in 1956. Attempts were then made to automate and remotely operate this new equipment. Remotely operated longwall face (ROLF) installations were operated in the U.K. and had limited success where conditions were good. They consisted of batch control of the chock supports and shearer control from the face end through cable transmission. Automatic horizon control was quickly found to be an essential feature of any remotely operated system and development of suitable transducers commenced.

A demonstration fully automated colliery, Bevercotes, was developed in the mid-1960's, but the concept was unsuccessful and was abandoned in 1969.

The mixed performance of these early remote and automated longwall faces was due to a number of factors:

- The coal industry was only just moving to mechanization so that management and men were not attuned to the demands of automated faces. Less than 25% of longwall faces in Europe had powered supports at this time.

- The application of electronic control technology to the hostile environment underground was insufficiently developed.
- The type of supports used were suitable for good conditions, but made automation in an adverse geologic setting difficult.
- Face operations, equipment and transducers were still too unreliable to automate with any consistent success.

The benefits of automation were recognized as improved safety, increased production and productivity, better seam recovery, less rock dilution and lower maintenance costs. These benefits made the coal industry continue to pursue the goal of remote and automatic control of coal mining operations. Major development work undertaken in Europe and U.S.A. improved the reliability of the various system components. At the same time, significant technology changes were occuring:

- The acceptance of heavy duty equipment on faces including high powered shearers and shield supports with high setting pressures.
- The introduction of electrohydraulic valve controls for roof supports.
- The rapid advance in microcomputer technology.

After a decade of consolidation during the 1970's, the drive to automation and remote control of longwall faces has made rapid advances during the 1980's. This report documents the state-of-art on this subject and how the latest technology could be applied to the Sydney Coalfield.

1.2 SCOPE OF WORK

The scope of work for this review is summarized as follows:

.1 Through literature search, telephone conversations, correspondence with manufacturers and equipment suppliers, to review the range of remote and automated control systems available for longwall mining.

.2 From the review made in .1, determine combinations of such systems and equipment that could be applied to:

- Advancing longwall faces.
- Retreating longwall faces.

On faces of lengths from 150 m to 200 m (500 ft to 650 ft) with thickness of extraction between 1.35 m and 2.5 m (4.5 ft to 8 ft) and daily production rates from 2600 tonnes to 4000 tonnes using plows and 4000 tonnes to 6000 tonnes with shearers.

.3 To discuss:

- The advantages.
- The disadvantages.
- The safety.
- The reliability.
- The maintenance.
- The cost effectiveness.
- The ease/difficulties of installation.
- The degree of training required for each combination reviewed in .2.

.4 To recommend a system or a combination of systems particularly applicable to conditions in the Sydney Coalfield.

.5 Prepare a report.

1.3 STUDY EXECUTION

Development of automated and remote control systems has primarly been carried out by the major European equipment manufacturers in conjunction with the British and German coal industry research organizations.

The application of the technology, however, tends to be spearheaded by the competitive coal industries in the U.S.A., Australia and Canada. Thus the state-of-art review has concentrated, by necessity, on the developments in Europe and primarily in the U.K. and Germany. It has covered high technology systems available in the market place and new developments still under research that will be ready for introduction or trials within two years.

Longwall mining machinery manufacturers and research organizations were contacted throughout Europe and North America for information. Leading equipment suppliers were visited. Extensive discussions were held with British Coal's specialists.

The report describes the equipment used on longwall faces and their methods of operation. It discusses the control of the coal getting machines and support systems. Methods of data transmission are outlined and how the individual equipment systems can be combined to give a comprehensive face package described. Benefits of control systems are appraised. The existing conditions and practices in the Sydney Coalfield have been documented and the potential for further automation assessed.

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 2.0 - LONGWALL MINING SYSTEMS

TABLE OF CONTENTS

2.0 LONGWALL MINING SYSTEMS

- .1 INTRODUCTION
- .2 LONGWALL FACE LAYOUTS
  - .1 Longwall Advancing
  - .2 Longwall Retreating
- .3 EQUIPMENT COMPONENTS
- .4 METHODS OF OPERATION
  - .1 Bi-directional
  - .2 Uni-directional
- .5 SUPPORT CONFIGURATION
  - .1 Immediate Forward Support
  - .2 One Web Back Working
- .6 CONTROL PHILOSOPHY

FIGURES

2-1 Immediate Forward Support
2-2 One Web Back

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

2.0 LONGWALL MINING SYSTEMS

2.1 INTRODUCTION

In longwall mining, production of coal takes place along a continuous length of face, or wall, between two access entries. With the development of a continuous mining machine travelling along a flexible armoured conveyor integrated with mechanized roof support, the whole operation can now be automated and ultimately remotely controlled. This background section describes some of the layouts currently being operated and notes terminology being used.

2.2 LONGWALL FACE LAYOUTS

Present mining systems incorporate the following layouts:

- Longwall advancing.
- Longwall retreating.

.1 Longwall Advancing

In this system, the entry development takes place simultaneously with face production, such that entry support is installed at the face ends and services are extended as the face advances.

A modification to this system is the "Advance Heading" technique where one or both of the entries are driven in advance of the coal face permitting the mining of the entries to take place independently of face production. In the case of advance mining, some form of support is required at the edge of the entry, both for support of roof and sides and also to route fresh air through the face. This support has to be temporarily removed from advanced heading faces when the cutting machine reaches the gate, making automation difficult.

.2 Longwall Retreating

In longwall retreat methods, the coal face is blocked out between two previously formed entries. As coal is produced, the face moves back along the entries permitting a shortening of services and maintaining a ventilation circuit along the entries and through the face.

The significant advantages of retreat mining are:

- The system is uncomplicated.
- The face is operating in a proven area.
- Transport and travelling are efficient and safer in undistorted roadways.
- Face ends are simplified and safer.
- Smaller teams of men are more easily supervised.
- Faster moving faces create improved conditions.
- Ventilation methods and the working environment are greatly enhanced.

This method of mining is particularly suited to remote control and automation.

2.3 EQUIPMENT COMPONENTS

Main components for the operation of a longwall face are:

- Cutting machine - in this study both shearers and plows are examined.
- Face conveyor (AFC) - a flexible armoured face conveyor.
- Face supports.
- Face end equipment.
- Entry drivage.

On modern longwall installations, all the components must be compatable and suitable for local conditions, i.e.:

- The shearer or plow must be capable of cutting and loading the required section of coal.
- The face conveyor must be capable of transporting the cut coal both in size and rate.
- The face supports must be integrated with both the rate of cutting and movement of the conveyor.
- The face end equipment must be capable of clearing the coal into the entry conveyor and moving the face equipment at the ends as coal is extracted.
- The rate of entry drivage must be capable of exceeding the rate of face advance.

2.4 METHODS OF OPERATION

The two main methods of operating the cutting machines are:

.1 Bi-directional

Where the machine is capable of cutting in both directions along the face, permitting the conveyor and supports to be advanced as soon as the machine has cut the coal.

.2 Uni-directional

Where the machine cuts the whole length of the face before the conveyor and supports can be moved forward. The conveyor and supports are advanced following the return run of the cutting machine (termed flitting).

The bi-directional cutting theoretically should permit the greater production and tighter roof support, In practice, this may be offset by methane and dust on the return side and less available cross-sectional area open for ventilation.

The uni-directional cutting permits the operators to be in a relative dust and methane free atmosphere and for face clean-up during the flitting run before the conveyor and supports are advanced. Where the coal section warrants a ranging drum, the leading drum can be programmed to cut to a roof horizon and the tailing drum to a floor horizon. This clean up helps control of the face line and to ensure a full web can be taken on the next cut.

2.5 SUPPORT CONFIGURAITON

Two arrangements of support are in use in modern mines.

- Immediate Forward Support (IFS). Usually for bi-directional working, Figure 2-1.
- One web back, Figure 2-2.

Support advance and conveyor advance can be controlled by a single operator.

.1 Immediate Forward Support

The initial condition for conventional bi-directional working is with the support advanced to the conveyor. The sequence of operations when the machine has passed is then as follows:

- Advance conveyor.
- Advance support and set legs.

Figure 2-1 shows the ideal operator's position for left or right hand working, enabling the operator to be positioned on the clean air side of the machine.

.2 One Web Back Working

The initial conditions for one web back working is with the conveyor advanced to the face and the supports set one web back from the Armoured Flexible Conveyor (A.F.C.). The sequence of remote operation is then as follows:

- When the machine has passed, release, advance and reset the support.
- Advance the conveyor.

Figure 2-2 shows the ideal operator position for left or right hand working enabling the operator to be positioned on the clean air side of the machine.

2.6 CONTROL PHILOSOPHY

Mining coal presents unique problems in control since coal being a sedimentary rock, varies widely in chemical, physical and mechanical properties and may contain methane gas and water. Seams can thicken or thin over short distances, undulate and in places, are faulted or eroded. Roof and floor conditions may vary within the length of a longwall panel. These variations make any control philosophies based on predictive modelling or assumptions of uniform seam conditions unsatisfactory.

Any system designed to mine a coal seam must be able to control the extraction equipment by sensing the interface between the coal bed and its enclosing strata. The cutting machine must be capable of mining seams that vary in physical properties, thickness and undulate; the conveyor system must follow closely the cutting operation and clear the coal from the face at the rate it is produced and the roof must be supported adequately and continuously as the face advances.

Before a mining system can be expected to be controlled automatically or remotely, it must first be demonstrated that such a system can work reliably. The failure of early automation efforts were primarily due to the fact that the mining system itself did not work reliably over a range of conditions. Automatic control to a reliable system can enhance its performance while remote control can enhance safety of operating and productivity.

In ideal mining conditions, the cost of automation may not be justified while in poor conditions, modifications to the mining system may have more impact than automation.

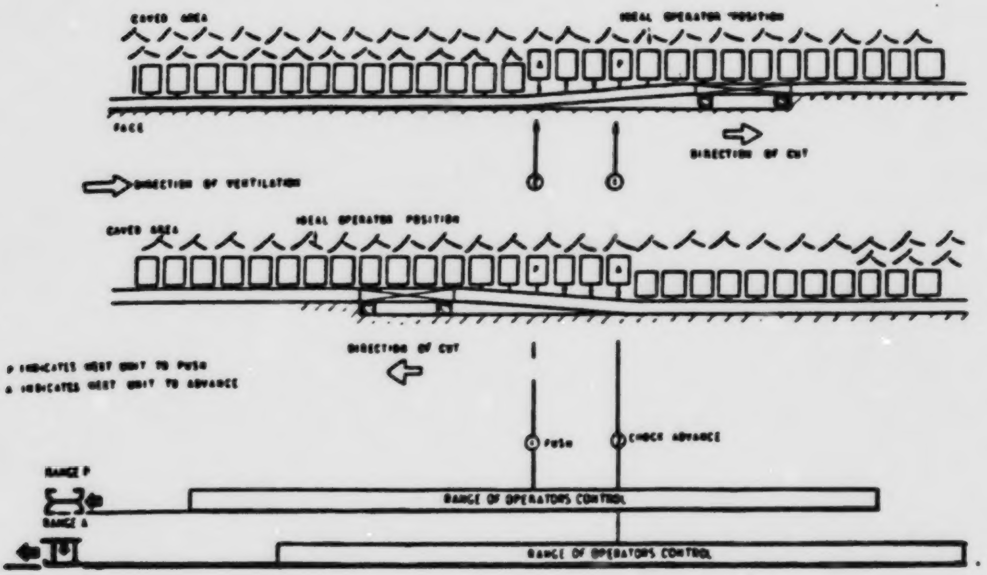
For the longwall face, there are three major sub-systems; the roof supports, cutting machine and face conveyor. Each of these work independently though efforts are being made to link them together. The introduction of micro-processors will allow these systems to be developed.

The development of gate entries under remote or automatic control has not yet been linked to face control. Hence, the approach to face automation is currently essentially the same for both advance and retreat mining methods. Only in plow systems is automatic face end reversal of the cutting machine achieved.

FIGURE 2-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

IMMEDIATE FORWARD SUPPORT

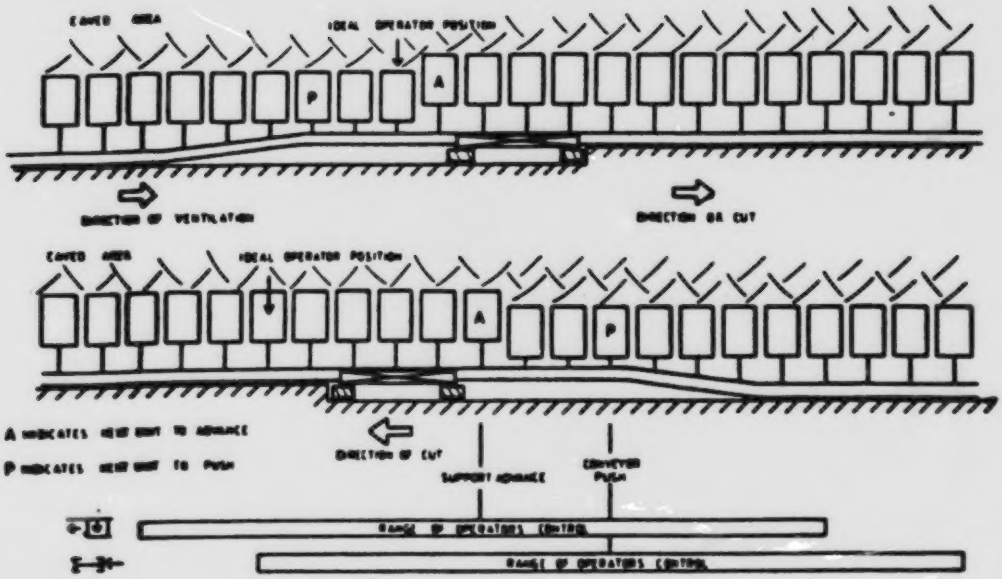

CAVED AREA
IDEAL OPERATOR POSITION
FACE
DIRECTION OF CUT
DIRECTION OF VENTILATION
IDEAL OPERATOR POSITION
CAVED AREA
DIRECTION OF CUT
P INDICATES NEXT UNIT TO PUSH
A INDICATES NEXT UNIT TO ADVANCE
PUSH
CHOCK ADVANCE
RANGE P
RANGE A
RANGE OF OPERATORS CONTROL
RANGE OF OPERATORS CONTROL

Source: Dowty

FIGURE 2-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

ONE WEB BACK


CAVED AREA
IDEAL OPERATOR POSITION
A
P
DIRECTION OF VENTILATION
DIRECTION OR CUT
CAVED AREA
IDEAL OPERATOR POSITION
A
P
A INDICATES NEXT UNIT TO ADVANCE
P INDICATES NEXT UNIT TO PUSH
DIRECTION OF CUT
SUPPORT ADVANCE
CONVEYOR PUSH
RANGE OF OPERATORS CONTROL
RANGE OF OPERATORS CONTROL

Source: Dowty

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 3.0 - ROOF SUPPORTS

TABLE OF CONTENTS

3.0 ROOF SUPPORTS

- .1 INTRODUCTION
  - .1 Manual Operation
  - .2 Pilot Operated Controls
  - .3 Batch Control or Group Automation
- .2 SUPPORT OPERATIONS
  - .1 Remote Push Button Control
  - .2 Free Running Batch Controls
  - .3 Remote Manual Control
  - .4 Bi-directional Adjacent Control
  - .5 Individual Hydraulic Support
  - .6 Special Customer Options
- .3 SUPPORT CONTROL SYSTEMS
  - .1 Support Unit
  - .2 Interface Pack
  - .3 Gate End Supply Unit
  - .4 Support Control Computers
  - .5 Dump Valve
- .4 SUPPORT MONITORING SYSTEMS
- .5 SUPPORT ALIGNMENT

FIGURES

3-1 Development of Face Supports
3-2 Usage of Face Supports
3-3 Powered Support Control System
3-4 Chock Interface Unit
3-5 Chock Interface Unit
3-6 Electroflex Control Unit
3-7 Hetronic 200/408 Control Unit
3-8 Electrohydraulic Control System MPS 4M
3-9 Panzermatic System
3-10 Interface Pack

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 3.0 - ROOF SUPPORTS

TABLE OF CONTENTS
(Continued)

3-11 Gate End Unit
3-12 Powered Support Control Centre
3-13 Central Unit
3-14 Central Control Unit
3-15 Gate End Computer
3-16 Support Monitoring System
3-17 Pressure Monitors
3-18 Monitor Display Unit
3-19 Mechanical Cord Transducer
3-20 Beckley Transducer Ram

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
APPLICATIONS FOR THE SYDNEY COALFIELD

3.0 ROOF SUPPORTS

3.1 INTRODUCTION

Roof supports have the functions of supporting the roof at all stages of the face advance, keeping the face area open, to induce a break line for the roof strata to cave, protecting face personnel from falls of material and to form an anchorage for advancing the conveyor system.

Supports have developed from simple wooden props to hydraulic props to self-advancing chock supports to the present shield supports (Figure 3-1). Figure 3-2 indicates the timing of these changes for Germany and shows that the move to shield supports occurred during the 1970's. The first attempts at automation of the supports undertaken during the 1960's were on four-leg chocks. The development of heavy duty powered supports of both chock and shield types provided the equipment reliability that, together with advancement of microcomputer technology, allowed remote control and automation to develop.

The control systems development were summarized by Kuti as follows:

.1 Manual Operation

Using:

- Cam operated poppet valves.
- Single lever rotary valves.
- Multi lever valve banks.

.2 Pilot Operated Controls (direct or adjacent)

Using coaxial, multi-duct hoses with:

- Single lever rotary selectors.
- Piano key or push button selectors.

The adjacent mode may be arranged for uni-directional or limited function bi-directional working.

.3 Batch Control or Group Automation

- Hydraulic impulse triggering the sequential operation of a single shield or a group of shields.
- Electrohydraulic system of sequential operation where the hydraulic impulse is replaced by an electrical impulse, but the pressure dependent sequencing of the individual functions is retained.
- Electrohydraulic system with electrical impulsing and sequencing using micro-processors. These control systems are generally designed to be triggered and observed by a shield operator, positioned on the fresh air side of the mining machine, but having visual control over support advancement.
- Remote control and machine dependent automatic sequencing of full face or part face support advancement.

The more recent developments in powered support control are described.

3.2 SUPPORT OPERATIONS

There are numerous types and variations of roof support available and their selection should depend on an assessment of site-specific conditions. Operation of the supports is by hydraulic rams which can raise/lower the canopy, advance the support and conveyor, advance/retreat front canopies/sprags, extend/retract side flaps and shields and lift the support base on support advance. Additional rams on specific supports can be used for gradient control and auto-creep on inclined faces. As mentioned previously, these hydraulic circuits were initially operated by manual valves on the supports, followed by adjacent and batch control of operation using hydraulic circuitry. The introduction of electro-hydraulic valves allied to micro-processors allowed a wide range of options to be integrated into support operations.

The cycle of an individual support depends to some extent on the method of mining operation selected (uni- or bi-direction, ISF or one-web back), but involves the operations outlined above.

The systems of support control in use include:

.1 Remote Push Button Control

Permits limited range remote operation of up to four support functions by one operator. These functions can be operated independently of each other from any support using push buttons located on the operator's support.

.2 Free Running Batch Controls

Automatic sequences can be initiated by a single control button. These sequences will move automatically to the operator up to and including the support adjacent to the operator's support.

.3 Remote Manual Control

Individual supports can be operated from the face and control station. Used primarily to correct the condition of the supports prior to operating a coaling sequence.

.4 Bi-directional Adjacent Control

Direct (hard wired) operation of solenoid valves/motorized valves provides this back-up system for use in difficult mining conditions.

.5 Individual Hydraulic Support

Available via local manual control valves for maintenance operation.

.6 Special Customer Options

Where standard systems are unsuitable, customized software can be supplied to meet a mines specifications.

3.3 SUPPORT CONTROL SYSTEMS

The control system for supports starts with the basic hydraulic layout which normally utilizes a remote pumping station for the hydraulic fluid. This system necessitates the use of high pressure steel pipes with low resistance joints from the gate end along the face. The volume and pressure requirements of the pumping system need to be determined for each installation.

The control system for the hydraulic circuits of the supports is by valves. Operation of the valves can be manual, solenoid activated or motorized. The latter two can be initiated by electro-hydraulic interfaces.

It is the introduction of these interfaces which has permitted the advancement of automatic and remote control of supports.

A control system, based on electro-hydraulic valves gear, consists of a number of components as illustrated in Figure 3-3. These can be summarized as:

.1 Support Unit

These units are mounted on the support housed in a metal box with a set of push buttons. Also built in are the highway connectors and the face micro-processors. By selection of the appropriate buttons, the hydraulic operations on the support are activated and a logical system of feedback to the support computer is achieved. The range of control can be "local" as well as sequential. Local control can be operated on one part of the coal face while sequential control is being carried out on another. Local control is always available. These units may be termed Chock Interface Units, On Face Units or Unit Control Station and various types are illustrated in Figures 3-4 to 3-9.

.2 Interface Pack

This pack (Figure 3-10) houses the electro-hydraulics interface valves, pressure switches and flow amplification. A machined metal housing where the manual "local" or pilot "sequential" solenoids/motorized valves are attached. Within the housing, the number of valve elements is varied as to the number of required functions. A maximum number is envisaged as six, giving control of:

- Lower and advance
- Set
- AFC push

- Forepole extend
- Sprag extend
- Sprag park

.3 Gate End Supply Unit

The functions of this unit is to provide intrinsically safe power supply to the roof supports to provide isolation between this power supply and that of the support computer. It can also take messages from the support computer, transform them into the correct format for the roof support equipment then transmit them and vice versa. These units can be termed Lockout Supply Units or Gate End Units (Figure 3-11).

.4 Support Control Computers

The computer, positioned at the gate end, fulfills the role of a coal face control and monitoring centre. There are connections to enable the powered supports, power pack, mining machine, AFC and stage loader to be linked up, depending on requirements, to the surface control room. The computer can be programmed using a variety of software to meet the method of operation of supports for a particular mine. It also provides face status and monitoring data and system diagnostics.

Memory capacity is large comprising RAM, EPROM and EEPROM. The RAM is expendable by modules to 1 Mbyte, is usually battery supportable and normally contains face status or monitoring data. The PROM contains the programmes for both control and monitoring. It is programmed in the factory in conjunction with the mine's mining engineers. The EEPROM can be occasionally changed when underground and access is via security code and in some cases, a key.

The computers vary in shape, but have key pad data entry and visual display of alpha numerical values for remote control for programming. Also there is graphical LCD display of system diagnostics.

The computers may be called Power Support Control Centre, Gate End Computer, Master Control Unit or Central Unit and are illustrated in Figures 3-12 to 3-18.

.5 Dump Valve

This is a solenoid operated hydraulic servo unit connected into the main or pilot supply to the face. During a lock out condition, the dump valve isolates the flow from the pumps and dissipates pressure in the face lines. The face electrical supply is interrupted simultaneously.

There are a number of major support manufacturers marketing support control systems including Dowty, Gullick Dobson, Hemscheidt, Westfalia Lunen/Siemens, Kloeckner Becorit, Eickhoff and Mitsui.

The bulk of installations to date have used Dowty or Gullick systems and these companies are undertaking significant research to achieve a higher level of sophisitication while maintaining reliability.

The German manufacturers have a substantial number of installations using their electro-hydraulic valve units both in Europe and the U.S.A.

Countries such as the U.S.A. and Australia are utilizing European technology for their longwall faces. Eastern European countries, while developing their own systems, adapt Western European electro-hydraulic valves to their own supports. Likewise, the Chinese do not consider their support controls advanced sufficiently for marketing internationally as yet.

A selection of company literature of available support control systems is provided as Appendix A.

3.4 SUPPORT MONITORING SYSTEMS

The purpose of a support monitoring system is to provide a diagnostic tool that can monitor a large number of parameters, via transducers and provide on site analysis of gathered information. The Dowty INSITE system is an example (Figures 3-16 and 3-17).

System hardware is designed to minimize the length of cables required to monitor remote transducers by using a single cable data collection highway on to which can be connected remote data collection units, sited local to the transducers. Each data collection unit can interface with up to eight transducers of either digital or analogue variety.

The Monitor and Display Unit (MDU) comprises an IS microcomputer complete with battery backed memory unit, real time clock, operator keyboard and full liquicrystal display facilities (Figure 3-18).

The computer accesses data from remote data collection units, analyses and stores acquired data, displays information on request and updates the watchdog timer to indicate MDU health.

The system undertakes routine scanning of inputs and displays on command of a series of summary charts. Specific monitoring tasks can also be selected via the keypad.

Various types of displays are available, including numerical, bar charts and mimic diagrams. The system is menu driven to enable information selection.

A remote data collection unit used for leg pressure monitoring and the total pressure monitoring of the support requires the fitting of hydraulic transducers directly into the supports hydraulic circuits.

Historical data can be displayed as each support is monitored during its set cycle and a record made of its setting pressure and line pressure at time of set. The display shows the condition of each support at time of set and a list of all those supports which do not reach a minimum pressure when set. Current pressure information is available, as after setting each support it is continuously monitored to provide an up-to-date record of support conditions. Displays available are the present condition of every support in bar graph and numerical form, a numerical list of all supports currently below a minimum pressure and a numerical list of all supports above a present pressure, i.e., areas of high pressure on the face.

Condition monitoring of supports can easily be carried out, since a record is automatically made of setting pressures at the start of the test period and current pressure displays gives the condition at the end of the test period. A comparison of the two sets of information provides information on the operational efficiency of the support. Additional information provided by the system can be the roof weight and closure rate monitoring. For leg pressure monitoring, a capacity of up to 1,000 transducers contained in up to 250 remote data collection units (RDCU's) is available. The RDCU's are series connected into a single cable supplied from the monitor and display unit.

Data can be retrieved from the monitor and display unit via a serial data link either direct to portable data logger or as hard copy via an intrinsically safe printer.

A more recent innovation under development is the introduction of a colour monitor to replace the LCD unit which is planned to incorporate machine information in addition to support monitoring.

Such systems would be expensive, but could be found to be cost effective due to reduced face manpower and fewer breakdowns on supports.

3.5 SUPPORT ALIGNMENT

It is accepted by mining engineers that straight face alignment is beneficial in terms of stress on the AFC and cutting machine, lower power consumption and equipment wear and particularly improved strata behaviour. These combine to improve safety and help increase output.

A number of attempts have been made to measure face advance. German and French instruments measured face advance by paying out wire or punched tape into the goaf. A number of problems arose relating to life of the wires, storage of data during power outages or electronic failures.

The Bergban-Forschung AFME unit pays out galvanized steel wire anchored in the goaf. The measuring unit consists of a electronic counter which stores the measured data, the selection electronics and a voice frequency multiplex system for serial data transmission. The precision of measurement of this method is better than ± 1%. The measuring units feed data to the control desk where they can be represented in numeric or analogue display.

The CERCHAR unit pays out a perforated tape with the end secured to the floor of the goaf. As the tape is paid out, a mini-circuit breaker closes as each perforation passes by. This information is passed to a control unit via a two-wire line situated in the AFC's spill plates. There are normally ten transducers placed along the face. The control unit displays face alignment as a series of lights and can initiate corrective action.

Recently, British Coal developed the cord alignment transducer (Figure 3-19) which works on the principle of measuring the withdrawal of cord from a reel enclosed within its casting.

As the cord is withdrawn, a pulley connected to a magnetically encoded disc is rotated. A "Hall Effects" sensor mounted adjacent to the disc detect its rotation and increments the electronic counter to record a distance measurement. The incrementing distance can be seen on an LCD on the transducer and also digitized for transmission to a remote monitor.

Cord transducers are mounted at regular intervals along the coal face with a spacing of up to nine supports between them. Connecting the transducers is a communications highway cable which supplies power to the units. Up to 60 transducers can be connected via a gate interface unit to a DC2 power supply.

Cord transducers can be attached either to the AFC spill plate or to the roof support, cord routing arrangement is installed to feed cord into the waste, where its loose end is anchored. As the AFC/support advances, the cord is withdrawn and the advance reading is incremented.

Values of advance from all the installed cord transducers are available for interrogation by the gate end monitor which requests the information regularly. The display on the gate end monitor shows either a tabular list of readings or a graphical outline of the coalface profile. Information can also be transmitted to the surface, plotted or stored by computer.

One method of straightening the face manually is to periodically make fly cuts with the cutting machine. The machine makes partial cuts and cleans up in front of the supports before they are fully advanced thus enabling the face line to be re-established.

Some support manufacturers claim that with modern heavy duty supports, full face advance is achieved and there is no neccessity for a face alignment monitoring or control system. This can normally be the case on conveyor advance where the ramp plates of the AFC allow it to push through any loose coal. However, supports may not move up fully if hard material wedges between the AFC and the support base.

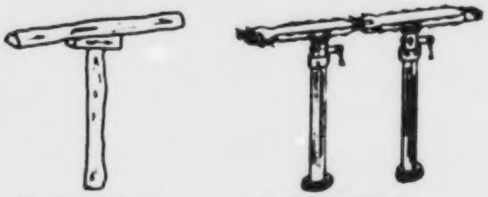
Manufacturers, despite their reservations, are developing alternative systems. Dowty is currently undertaking trials with a Beckley analog transducer to measure ram push. This analog system is based within the core of the ram itself and designed to measure full ram extension (Figure 3-20). Gullick are working on the premise that the amount of advance can be pre-determined and preset into the ram advance by an internal transducer.

The Gullick system can be programmed to enable the ram advance action to repeat up to three times to allow full ram extension/AFC pushover or until the transducer is tripped off at full extension.

FIGURE 3-1

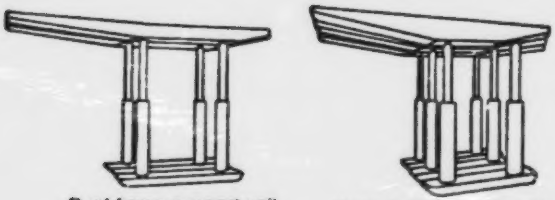
REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

DEVELOPMENT OF FACE SUPPORTS



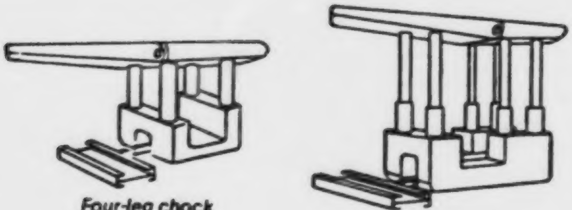
Single wood prop

Single steel props with articulated roof bars



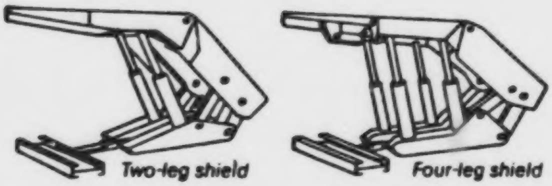
Dual-frame support unit

Triple-frame support unit



Four-leg chock

Six-leg chock



Two-leg shield

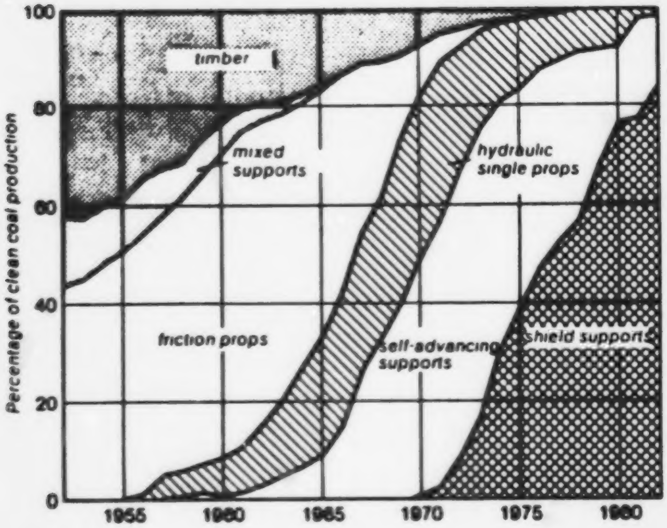
Four-leg shield

Source: Westfalia-Lunen

FIGURE 3-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

USAGE OF FACE SUPPORTS

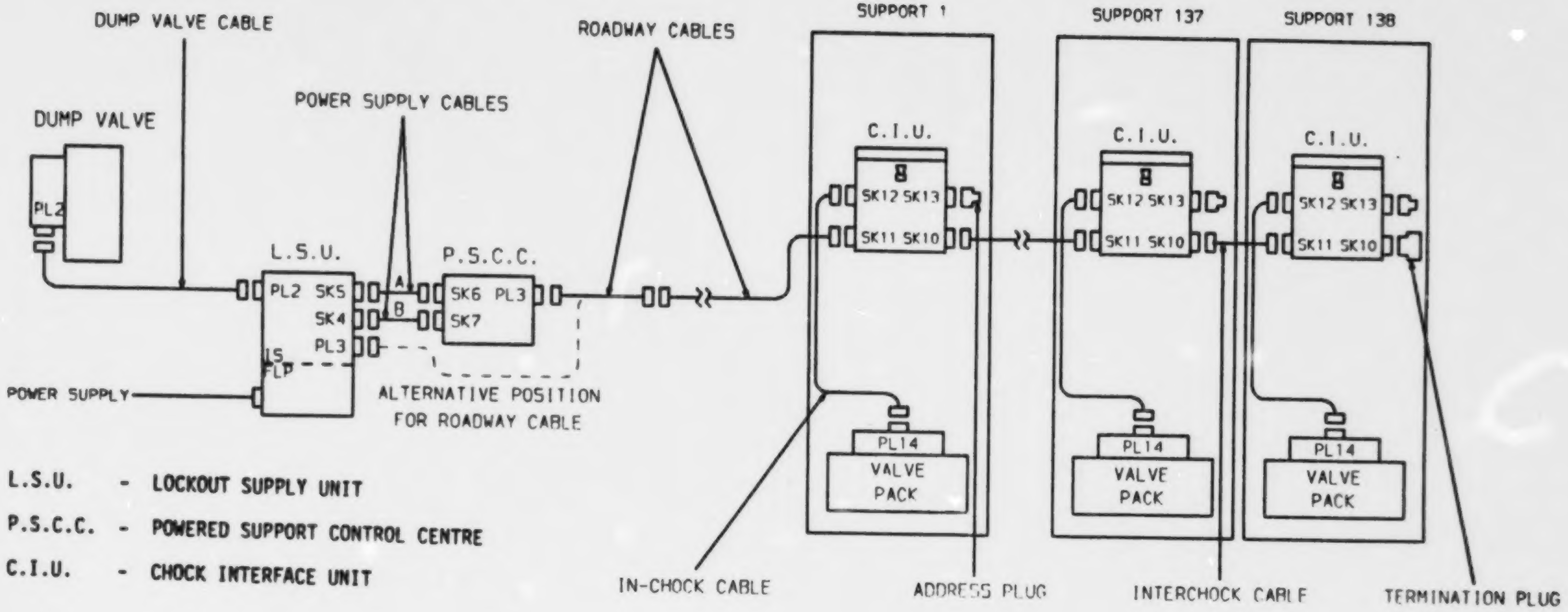


Source: Westfalia-Lunen

FIGURE 3-3

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

POWERED SUPPORT CONTROL SYSTEM


DUMP VALVE CABLE
DUMP VALVE
PL2
POWER SUPPLY CABLES
ROADWAY CABLES
SUPPORT 1
SUPPORT 137
SUPPORT 138
C.I.U.
SK12 SK13
SK11 SK10
8
L.S.U.
PL2 SK5
SK4
PL3
IS
FLP
A
B
P.S.C.C.
SK6 PL3
SK7
POWER SUPPLY
ALTERNATIVE POSITION FOR ROADWAY CABLE
PL14
VALVE PACK
IN-CHOCK CABLE
ADDRESS PLUG
INTERCHOCK CABLE
TERMINATION PLUG

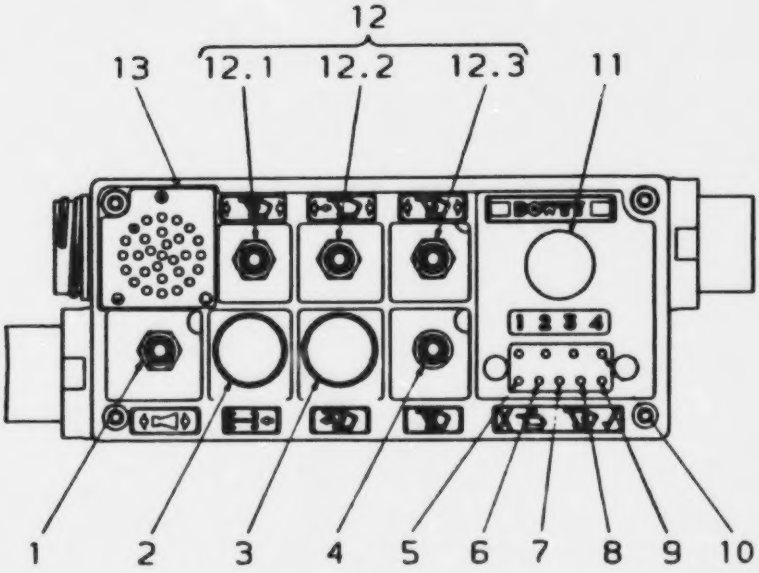
L.S.U. - LOCKOUT SUPPLY UNIT
P.S.C.C. - POWERED SUPPORT CONTROL CENTRE
C.I.U. - CHOCK INTERFACE UNIT

Source: Dowty

FIGURE 3-4

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CHOCK INTERFACE UNIT



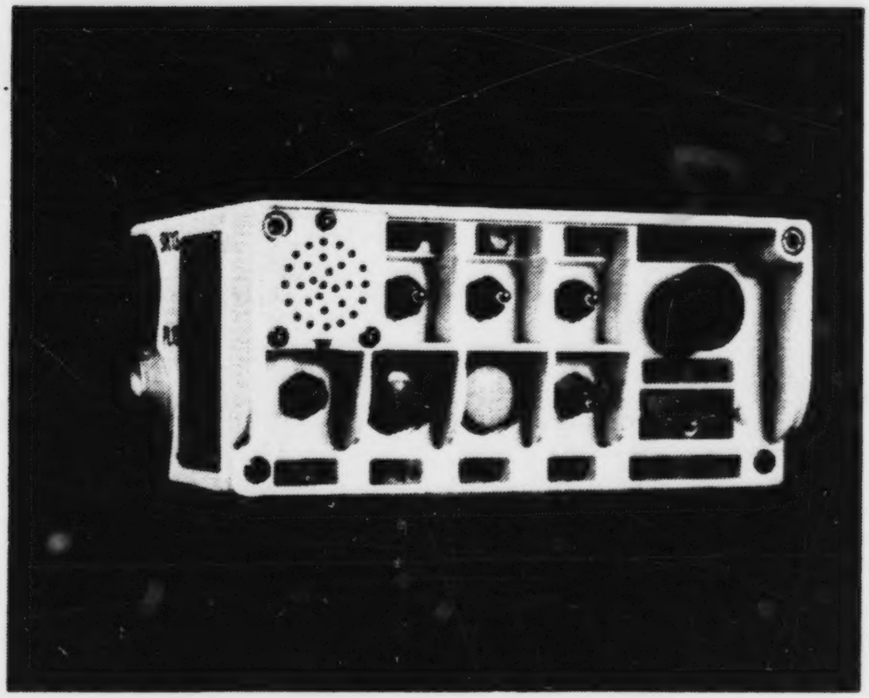
1	PRIME/DIRECTION SWITCH
2	CONVEYOR ADVANCE BUTTON
3	SUPPORT ADVANCE BUTTON
4	NORMAL/DISABLE SWITCH
5	FAULT INDICATOR SWITCH
6	SUPPORT LOWERED INDICATOR (YELLOW)
7	PRIMED SUPPORT INDICATOR (RED)
8	SUPPORT ADVANCED MONITOR (YELLOW)
9	SEQUENCE 'HEALTHY' INDICATOR (GREEN)
10	SOLENOID INDICATORS (YELLOW)
11	LOCKOUT BUTTON (EMERGENCY STOP)
12	ADJACENT CONTROL SWITCHES:
12.1	POWER LOWER
12.2	SUPPORT ADVANCE
12.3	SUPPORT SET
13	AUDIBLE WARNING UNIT

Source: Dowty

FIGURE 3-5

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CHOCK INTERFACE UNIT

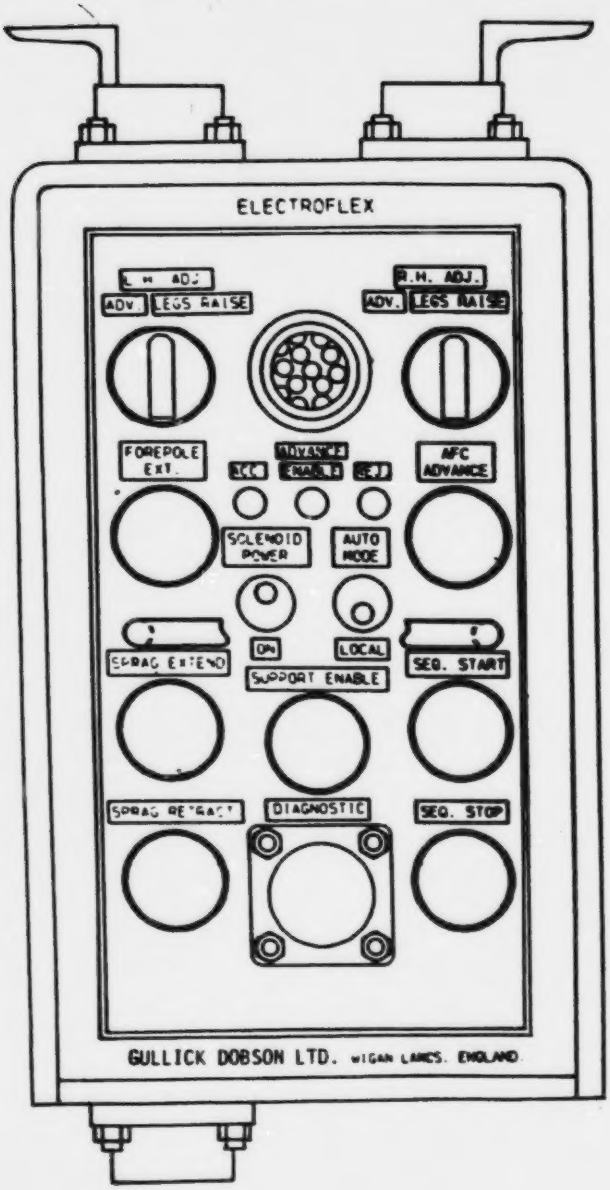


Source: Dowty

FIGURE 3-6

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

ELECTROFLEX CONTROL UNIT

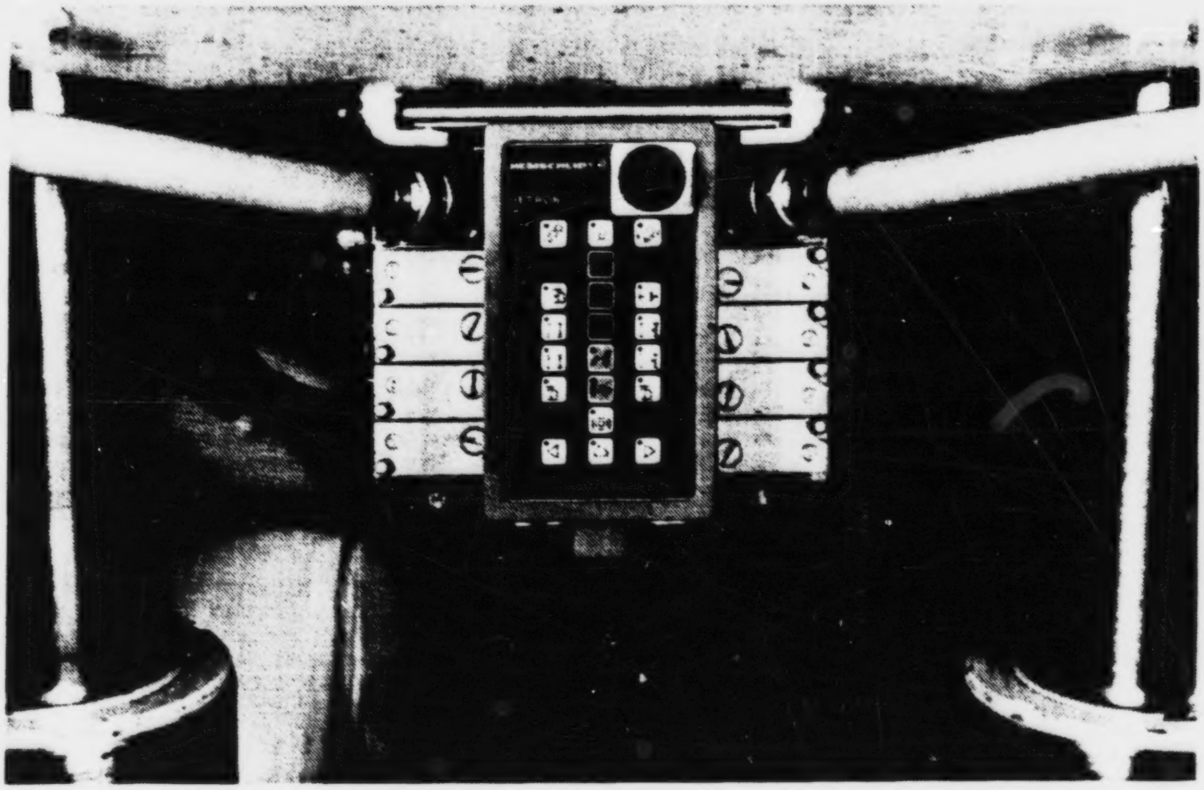

ELECTROFLEX
L.H. ADJ.
ADV.
LEGS RAISE
R.H. ADJ.
ADV.
LEGS RAISE
FOREPOLE EXT.
ADVANCE
ACC
ENABLE
REJ
AFC ADVANCE
SOLENOID POWER
AUTO MODE
ON
LOCAL
SPRAG EXTEND
SUPPORT ENABLE
SEQ. START
SPRAG RETRACT
DIAGNOSTIC
SEQ. STOP
GULLICK DOBSON LTD. WIGAN LANCS. ENGLAND

Source: Gullick

FIGURE 3-7

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

HETRONIC 200/408 CONTROL UNIT

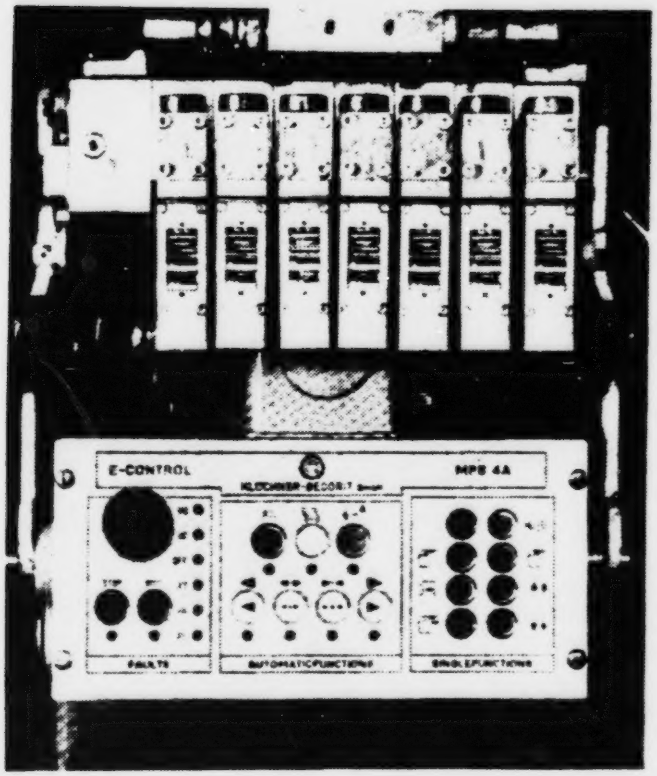


Source: Hemscheidt

FIGURE 3-8

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

ELECTROHYDRAULIC CONTROL SYSTEM MPS 4M

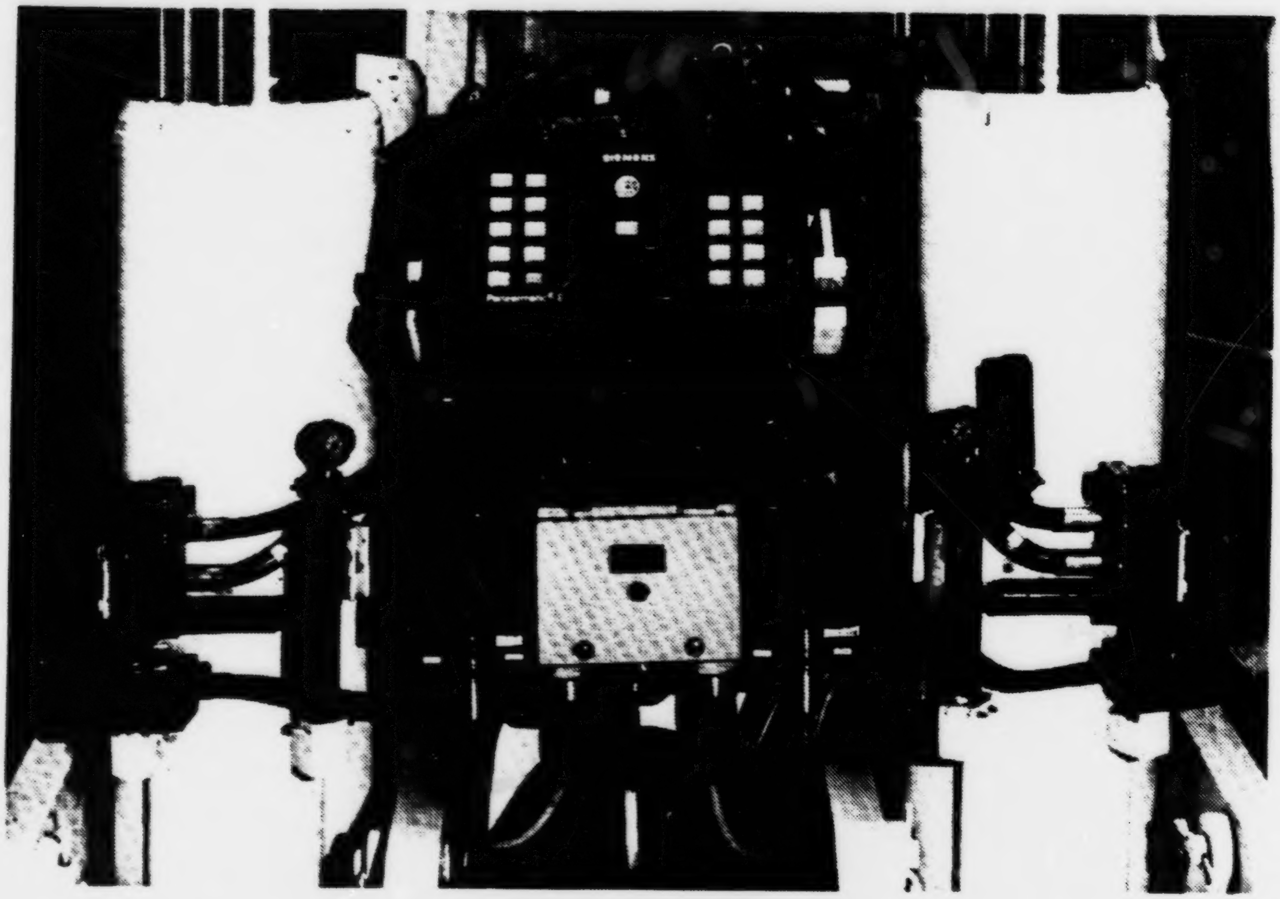

E-CONTROL
KLOECKNER-BECORIT GmbH
MPS 4A
FAULTS
AUTOMATIC FUNCTIONS
SINGLE FUNCTIONS

Source: Kloeckner-Becorit

FIGURE 3-9

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PANZERMATIC E SYSTEM

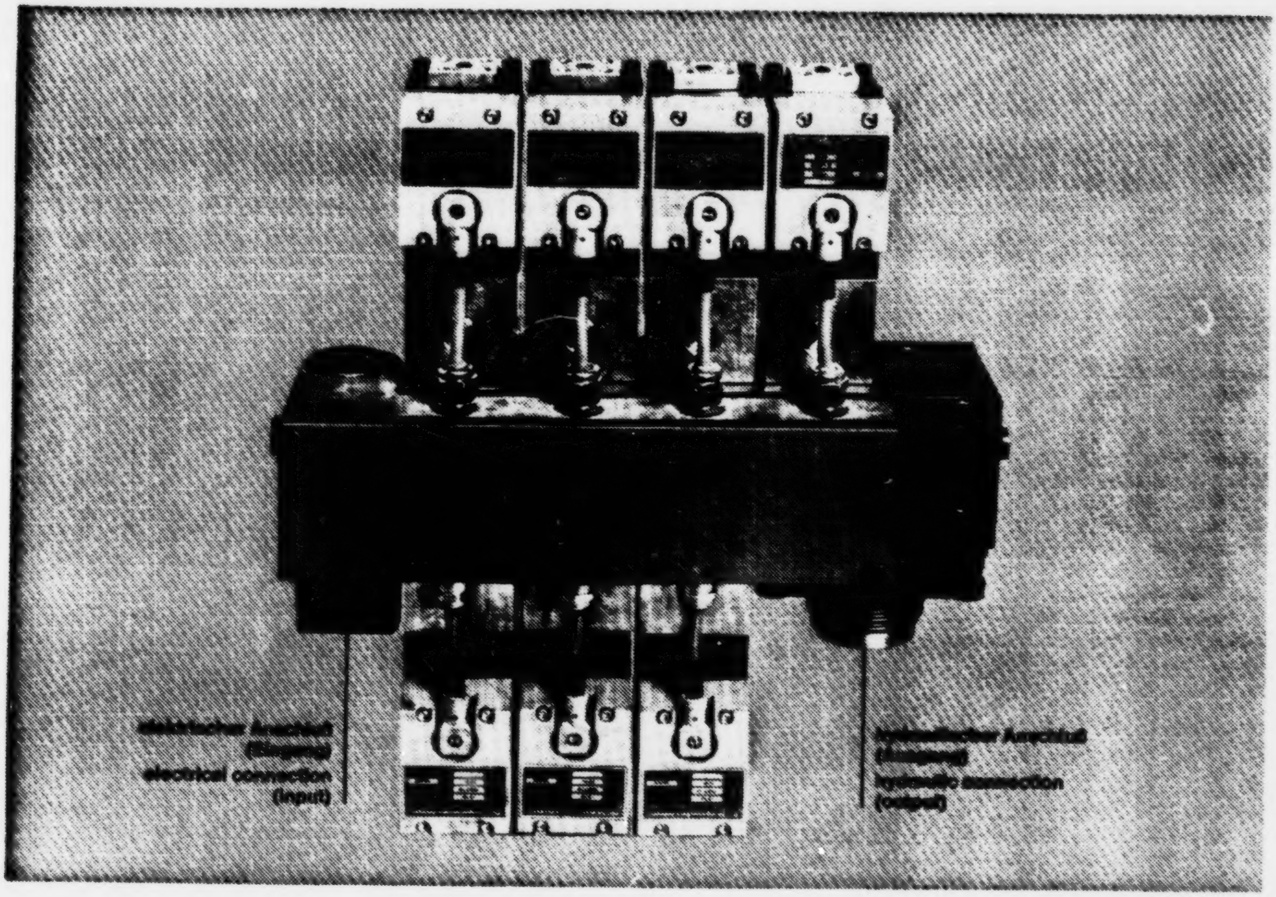


Source: Siemens

FIGURE 3-10

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

INTERFACE PACK

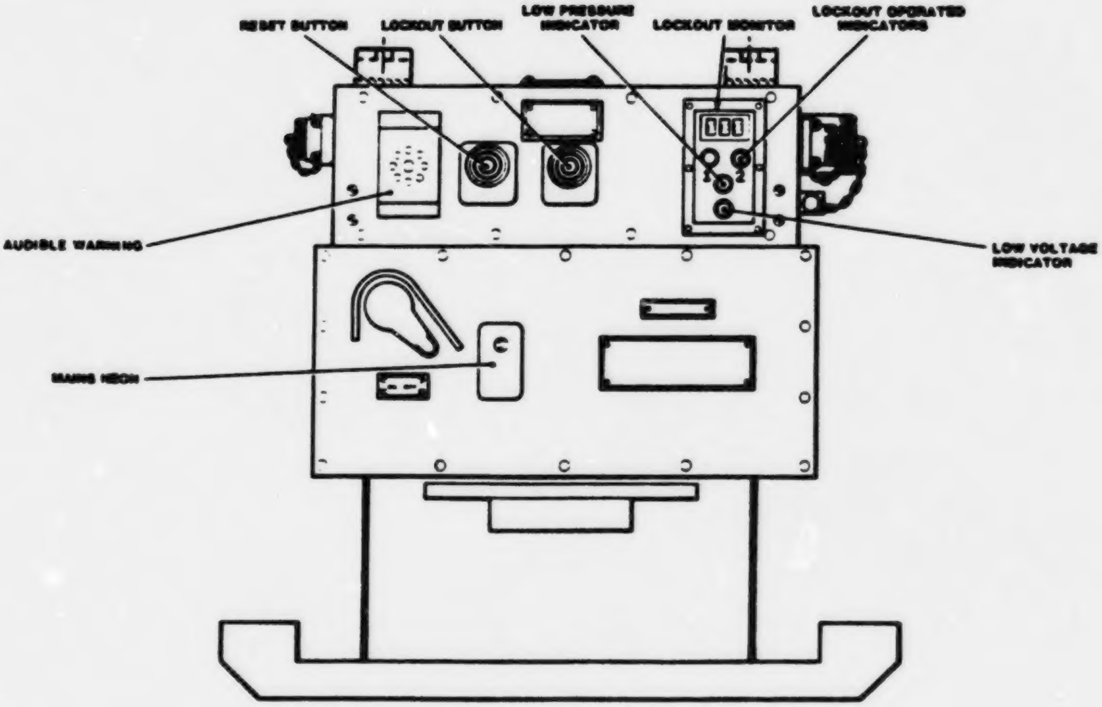

elektrischer Anschluß
(Eingang)
electrical connection
(input)
hydraulischer Anschluß
(Ausgang)
hydraulic connection
(output)

Source: Siemens

FIGURE 3-11

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

GATE END UNIT

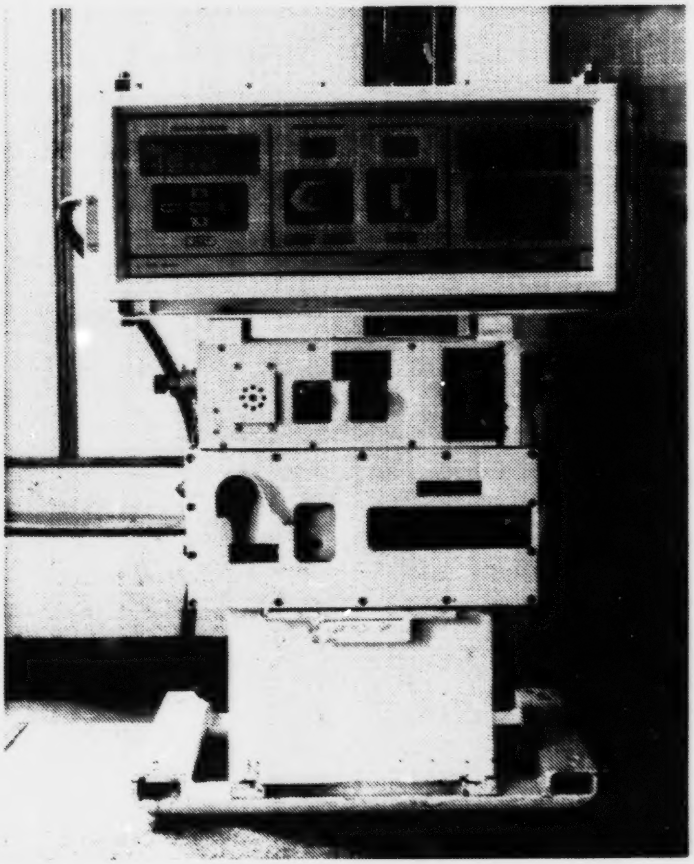

RESET BUTTON
LOCKOUT BUTTON
LOW PRESSURE INDICATOR
LOCKOUT MONITOR
LOCKOUT OPERATED INDICATORS
AUDIBLE WARNING
LOW VOLTAGE INDICATOR
MAINS NEON

Source: Dowty

FIGURE 3-12

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

POWERED SUPPORT CONTROL CENTRE

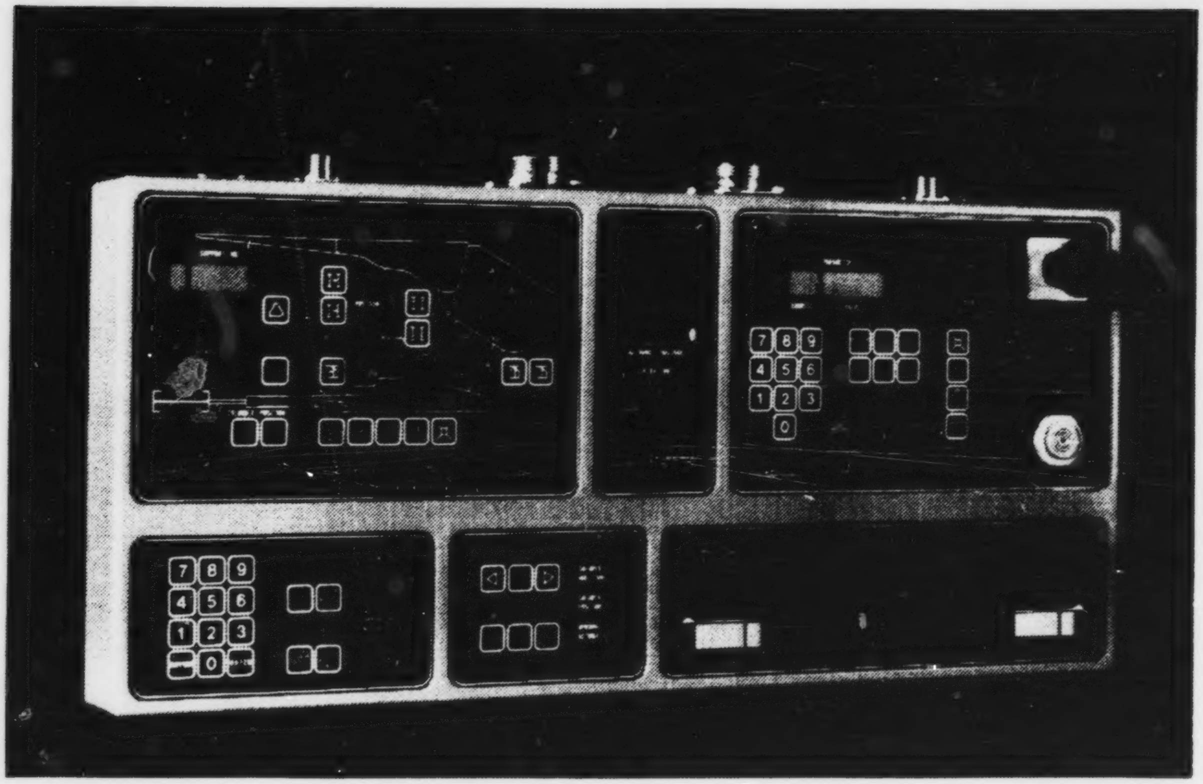


Source: Dowty

FIGURE 3-13

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CENTRAL UNIT



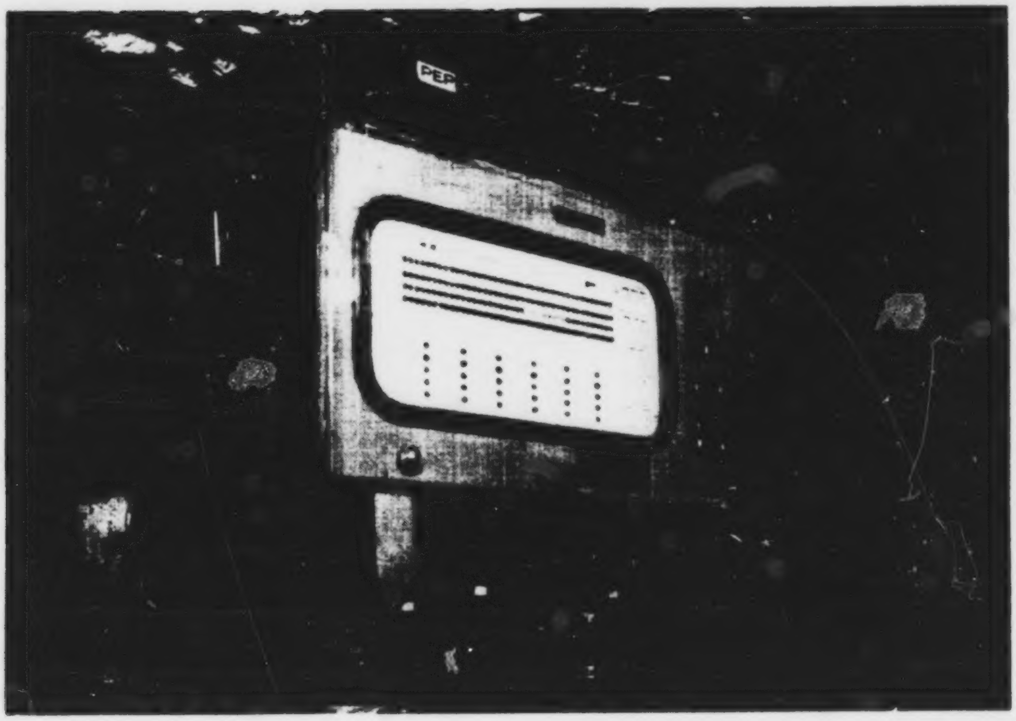
Source: Hemscheidt

FIGURE 3-14

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CENTRAL CONTROL UNIT

The central control unit at the Quarto No. 4 mine, Ohio, U.S.A.

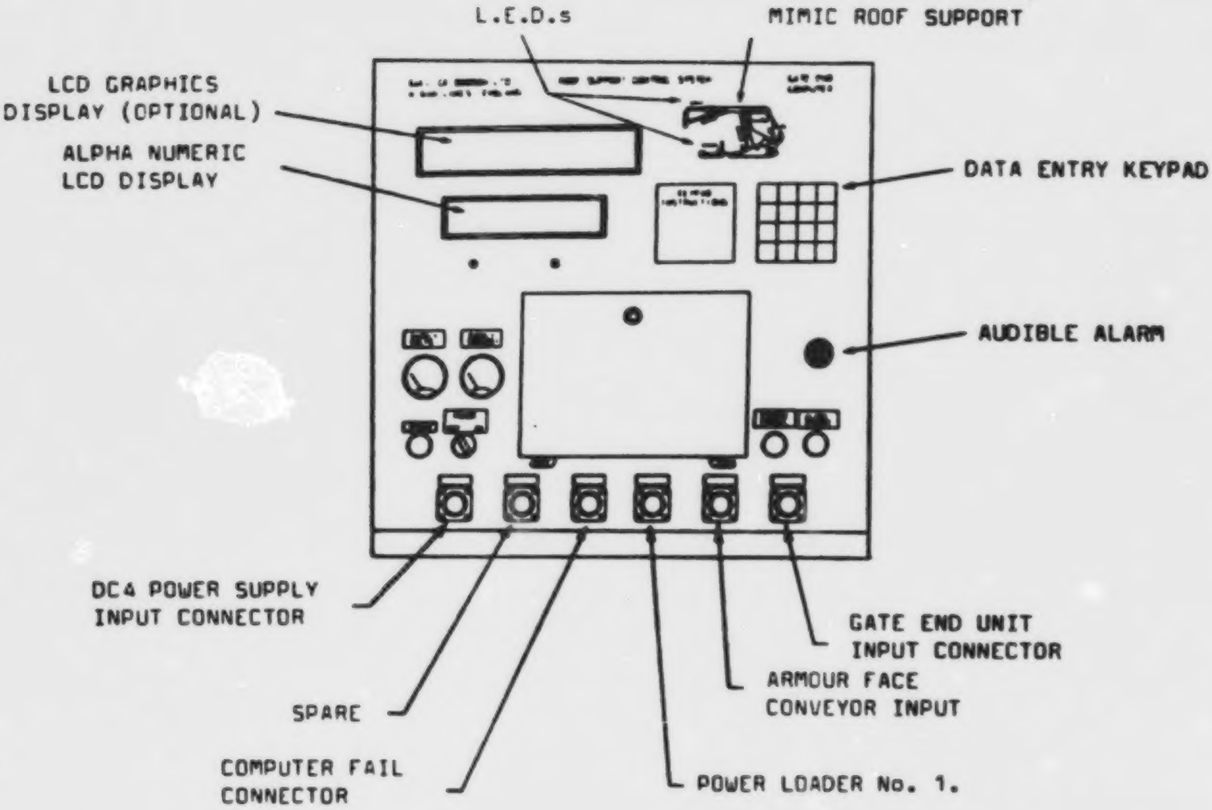


Source: Westfalia/Siemens

FIGURE 3-15

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

GATE END COMPUTER


L.E.D.s
MIMIC ROOF SUPPORT
LCD GRAPHICS DISPLAY (OPTIONAL)
ALPHA NUMERIC LCD DISPLAY
DATA ENTRY KEYPAD
AUDIBLE ALARM
DC4 POWER SUPPLY INPUT CONNECTOR
GATE END UNIT INPUT CONNECTOR
ARMOUR FACE CONVEYOR INPUT
SPARE
COMPUTER FAIL CONNECTOR
POWER LOADER No. 1.

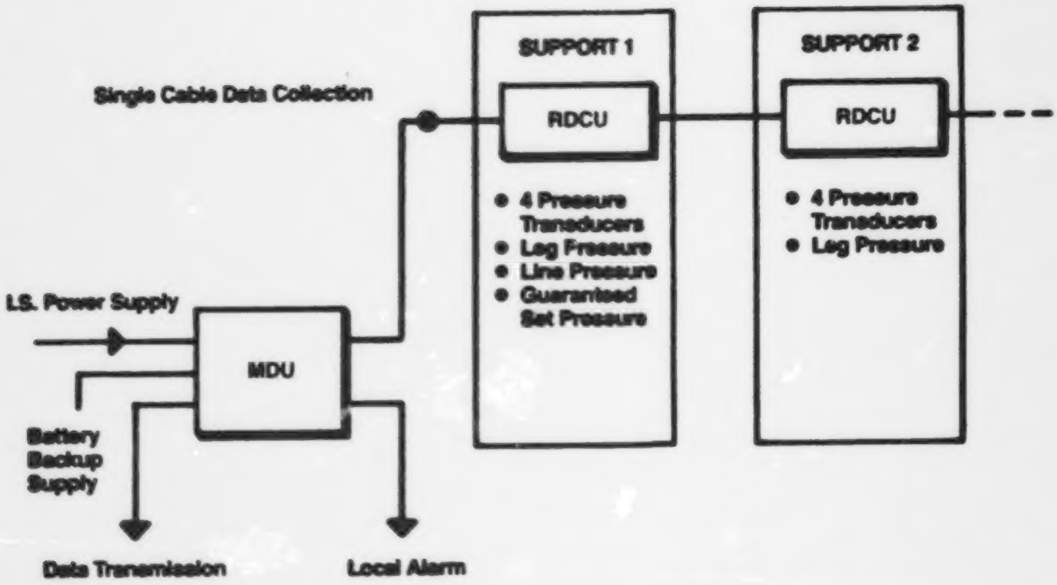
- GATE END COMPUTER

Source: Gullick

FIGURE 3-16

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SUPPORT MONITORING SYSTEM

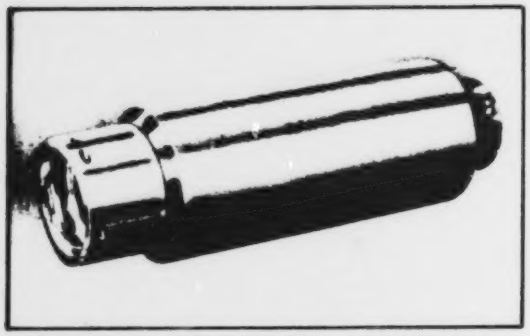

SUPPORT 1
SUPPORT 2
Single Cable Data Collection
RDCU
RDCU
• 4 Pressure Transducers
• Leg Pressure
• Line Pressure
• Guaranteed Set Pressure
• 4 Pressure Transducers
• Leg Pressure
I.S. Power Supply
MDU
Battery Backup Supply
Data Transmission
Local Alarm

Source: Dowty

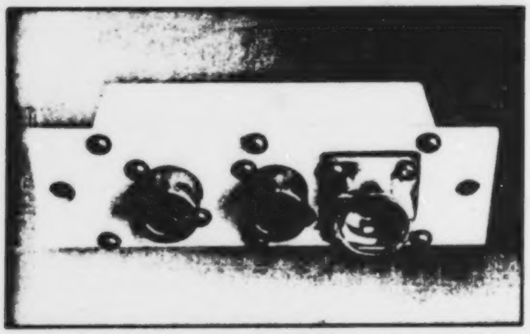
FIGURE 3-17

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PRESSURE MONITORS



SINGLE PRESSURE MONITOR



MULTIPLE PRESSURE MONITOR

SPECIFICATION

GENERAL; ENCLOSED-PERMITTED ALLOY CASE ENCLOSURE IP 67.

OPERATING RANGE	0–10,000 PSI (689 bar)
BURST PRESSURE	23,000 PSI (1585 bar)
OPERATING TEMP RANGE	−10°C – +50°C
HUMIDITY	—0 - 100% RH Non Condensing
ANALOGUE OUTPUT	
OUTPUT (BS 5754: 1980)	—0.4 - 2v into 1000 OHM
SUPPLY VOLTAGE	10 V dc – 16 V dc
CURRENT DRAIN	30 mA
NON LINEARITY	0.4% Full Scale
SUPPLY VARIATION EFFECT	0.1% Full Scale
TEMPERATURE ERROR	1.5% Full Scale over −10°C - +50°C
CONNECTORS	
PRESSURE	Compatible with Dowty size 20 staple (male, hose)
ELECTRICAL	12 way, medium shell, Dowty Staplelock.

RANGE

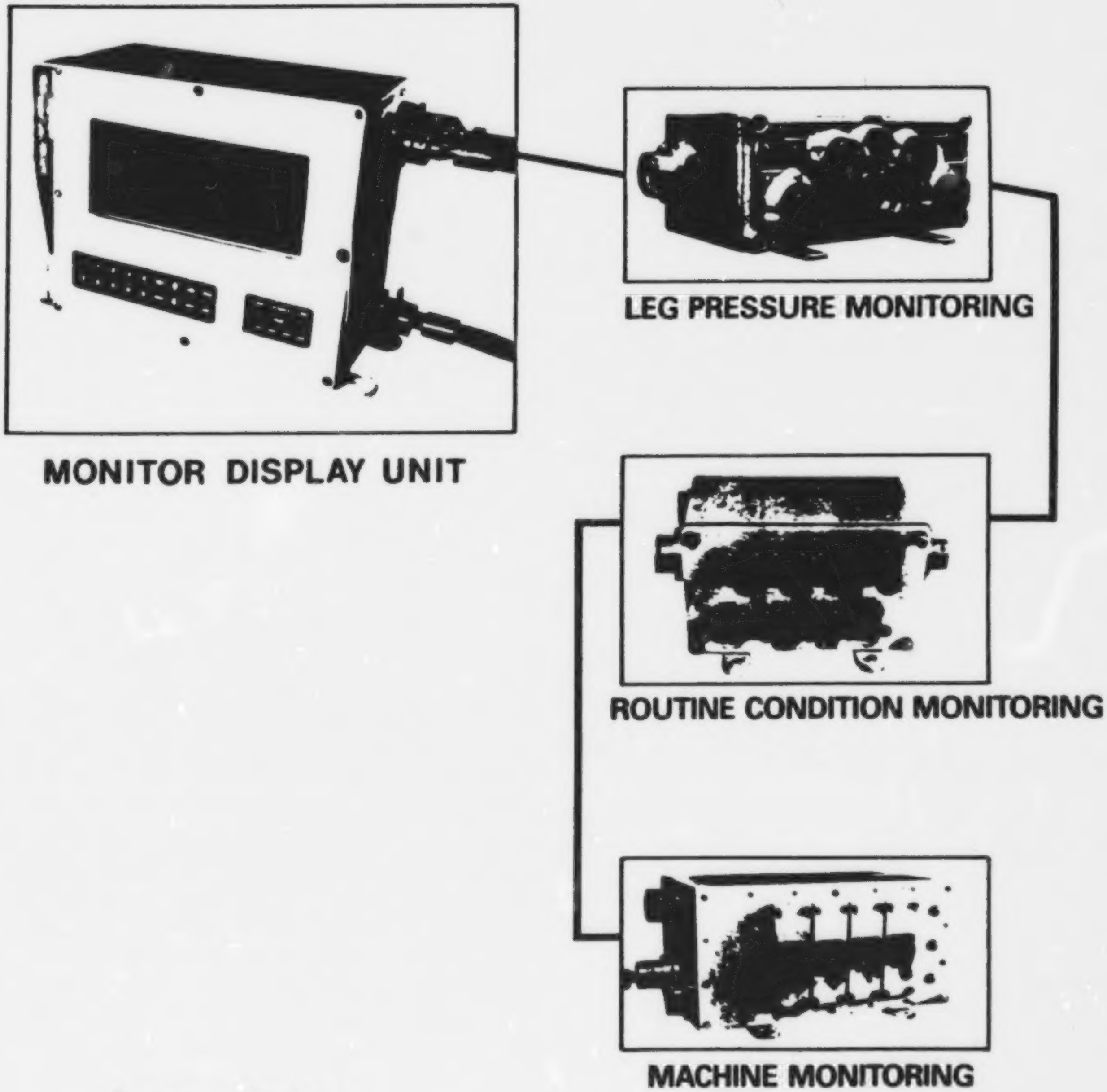
0–2500	P.S.I.
0–5000	P.S.I.
0–10,000	P.S.I.

Source: Dowty

FIGURE 3-18

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MONITOR DISPLAY UNIT


LEG PRESSURE MONITORING
MONITOR DISPLAY UNIT
ROUTINE CONDITION MONITORING
MACHINE MONITORING

Source: Dowty

FIGURE 3-19

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MECHANICAL CORD TRANSDUCER

Mechanical cord transducers have been used for some years as a means of recording the advance of the coalface at defined positions along its length. The transducer, which is mounted on the AFC furnishings or on the powered supports, consists of a case containing a reel of polyester cord and a mechanical revolution counter. The cord passes around a pulley on the counter shaft and out of the case through a protective tubing to the rear of the support, where the end is anchored in the waste. As the AFC or the support is advanced the total length of cord paid out is recorded on the counter to the nearest 0.01 m. A number of transducers can be spaced along the coalface and the advance of each can be read at any time during the cycle. A plot of these values reveals the alignment of the coalface.

The final version of the mechanical cord transducer is HQT 99190. Prototypes of this design were manufactured and tested at Bretby and these were installed underground in 1986.

The specification of this design is as follows:

Size (mm)
— 175 wide (215 over flanges) × 250 high × 105 deep

Weight (kg)
— 6.7

Counter limits (m)
— 0 to 9999.99

Resolution (m)
— 0.01

Accuracy
— Better than 1%

Cord reel
— 275 metres (Code KT 329/24)

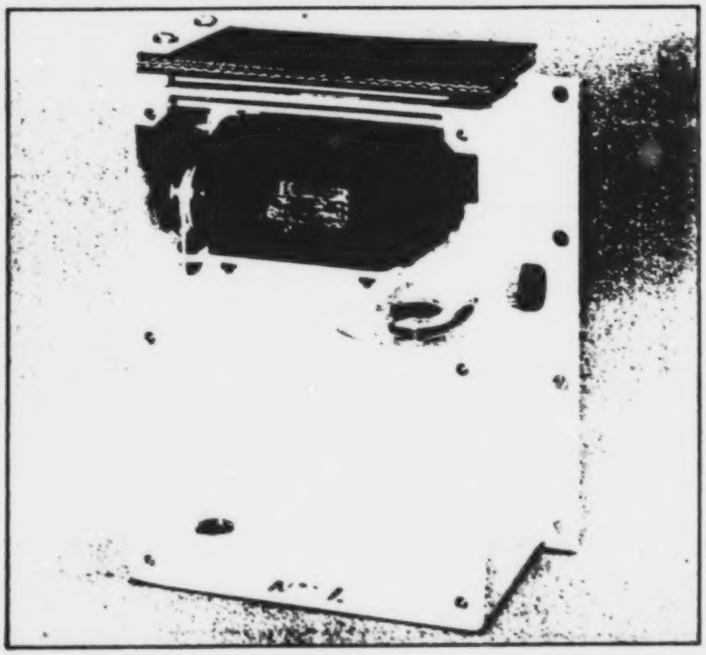
Case construction
— Fabricated steel

Counter
— Veeder Root No. 166925 — 900 (modified)

Viewing window
— On top surface (protected)

Estimated cost
— £400 (January 1987)

Availability
— Can be manufactured from British Coal Drawings by Contractors



Mechanical cord transducer (cover removed)

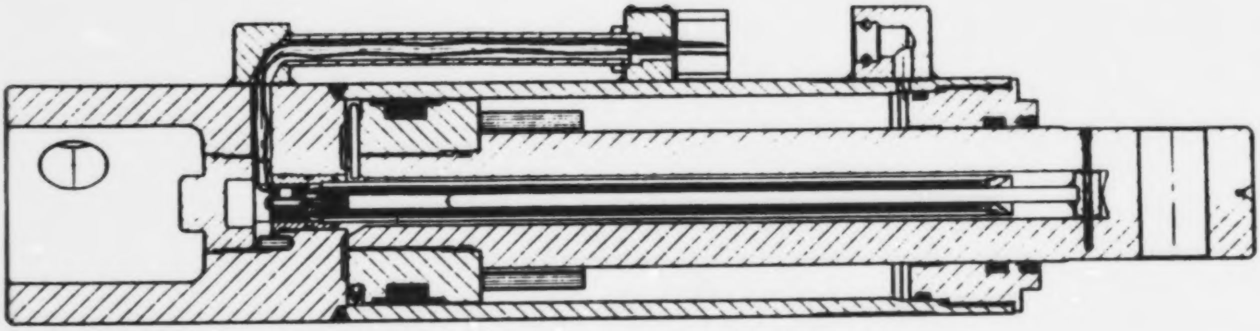
Source: British Coal

AR-122

FIGURE 3-20

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

BECKLEY TRANSDUCER RAM



Source: Beckley

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 4.0 - SHEARERS AND PLOWS

TABLE OF CONTENTS

4.0 SHEARERS AND PLOWS

- .1 INTRODUCTION
- .2 SHEARER CONTROL SYSTEMS
- .3 AUTOMATIC STEERING SYSTEMS
  - .1 Vertical Position Measurement
    - .1 Natural Radiation Sensor
    - .2 Pick Force Sensor
    - .3 Recognition
  - .2 Tilt Transducers
  - .3 Roof Height Transducer
  - .4 Boom Transducer
  - .5 Machine Movement and Direction Detector
  - .6 End of Face Detector
  - .7 Direction Pressure Transducers
  - .8 Control Systems
    - .1 Control Unit
    - .2 Personality Unit
    - .3 Power Supply Unit
    - .4 Multiplexer
  - .9 Adaptive Automatic System
- .4 SHEARER POSITION INDICATION
- .5 SHEARER CONTROLS
- .6 CONDITION MONITORING
- .7 EXPERT SYSTEMS
- .8 PLOWS
  - .1 Plow Travel Indicator
  - .2 Control of Depth of Plowing
    - .1 Fixed Pressure Control
    - .2 Fixed Distance Control
  - .3 Monitoring of Face Alignment and Face Advance Measuring System

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 4.0 - SHEARERS AND PLOWS

TABLE OF CONTENTS (Continued)

.4 Electronic Monitoring of the Plow
.5 Monitoring of Gradient
.6 Remote Operation of Roof Supports

FIGURES

4-1 Steering Transducers - DERDS
4-2 Steering Control Equipment - SERDS
4-3 Natural Radiation Sensor
4-4 Machine Movement and Direction Detector
4-5 End of Face Detector
4-6 Shearer Control Layout
4-7 Control Unit MRD 90001
4-8 Personality Unit
4-9 MIDAS Control System - Steering Algorithm
4-10 MIDAS Control System - Ranging Arm Loop Control - Double Pass Operation
4-11 Shearer End Control Unit
4-12 Control Layout for AM.500 RDS
4-13 Machine Control and Health Monitoring System
4-14 MIDAS Condition Monitoring
4-15 Data Access and Display Unit
4-16 Debris Transducer
4-17 Expert System Concept
4-18 Expert System Printout
4-19 Plow Outrigger System
4-20 Plow Outrigger Steering System
4-21 Automatic Face Alignment

4.0 SHEARERS AND PLOWS

4.1 INTRODUCTION

The remote and automatic control of longwall mining machines such as plows and shearers give the benefit of greater safety, increased production/productivity, increased seam recovery, decreased dilution and lower maintenance costs.

Full automation of the longwall extraction process requires three-dimensional control.

Guidance in the vertical dimension is needed to set roof and floor horizons in accordance with pre-determined plans. This is achieved by use of horizon control systems, which allow the operator to supervise the machine operation from a safe vantage point and to take control at the face ends and during face disturbances.

Control of the longitudinal axis is required to prevent the formation of steps in the floor or roof as the machine rolls for any reason which could create problems with roof support and face advance.

The heading of the machine is determined by the position of the roof supports and the extension of the AFC pull rams.

Other parameters that need to be known and controlled include haulage speed, direction of travel and machine position on the face. Linked with machine condition monitoring, the successful application of these control systems can lead eventually to remote and automatic control of the mining machine and the mining system. This section outlines the more recent developments in shearer and plow controls.

4.2 SHEARER CONTROL SYSTEMS

While the control of shearers depends to some extent on the type of shearer in use, the principles are essentially similar. Earliest shearer models were single ended fixed drum which are not suitable for seams with variable thickness and floor or roof undulations. These deficiencies were overcome with the single ended ranging drum shearer (SERDS). However, when the seam exceeds a certain thickness, the shearer cannot cut the entire seam height and a return cutting trip is necessary. A tailgate stable hole has to be separately driven to allow the machine to reverse.

Double ended ranging drum shearers (DERDS) are currently the most popular shearer since they can cut the entire seam in one trip. The machine can operate cutting uni-directionally or bi-directionally.

Other variables in shearer design are:

- Location of drums, either one boom arm mounted each side of shearer body or both boom arms on same side.
- Ranging arm or gearhead shearers.
- In-web shearer or conveyor mounted.
- Type of haulage; chain or chainless.

Shearer design by U.S.A. manufacturers, Joy Technologies, was based on their experiences with machines for the room and pillar method. They developed an all electric range of shearers.

European and Japanese suppliers have followed this lead and developed all electric shearers themselves such as the Mitsui Mike's Trojan and Anderson Strathclyde Electra 550. These present new opportunities for control systems.

The report considers the control systems developed mainly for the modern high production SERDS and DERDS, conveyor mounted and normally with chainless haulage.

The control systems can be broken down into:

- Machine guidance or automatical horizon control.
- Remote condition monitoring.
- Haulage speed control.
- Radio control.
- Integrated systems such as support initiation.

Operations of the shearer that can be operator initiated include:

- Machine speed.
- Machine direction.
- Arm ranging.
- Cowl movement.

4.3 AUTOMATIC STEERING SYSTEMS

Research and development of automatic steering systems have been undertaken in the U.K., Germany, U.S.A. and other countries since the early 1960's. However, of the systems in operation, the most advanced have been developed in Britain, with Germany becoming active.

Steering systems require a number of transducers for:

- Reliable and accurate determination of coal thickness continuously along the face, including the position of the cutting drum within the seam or last cut location.
- Measurement of machine angle, relative to seam angle, in direction of face advance (tilt transducer).
- Determination of the vertical position of drum relative to the previous cut (roof height transducer).
- In two-pass mining, measurement of actual coal extraction (boom height transducer).
- Indication of machine direction of travel and position along the face (machine direction and machine position detectors).
- Identification of the main gate end of the face (end of face detector).
- Direction of machine movement (direction pressure transducers).

An example of the location on a DERDS of these transducers is shown in Figure 4-1 and for a SERDS in Figure 4-2.

.1 Vertical Position Measurement

Systems require the position of the cutting drum within the coal seams to be known.

.1 Natural Radiation Sensor

The transducer employed to measure the thickness of roof coal is the Natural Radiation Sensor (Figure 4-3), which has been in use for some years in coal thickness indication systems. It has been found that most roof shales in coal mining emit a measurable amount of radio activity. Coal, due to its density, will act as an absorber of the radiation from the overlying shale. The degree of aborption will increase as the thickness of coal increases, thus providing a method to measure the amount of roof coal being left during shearing. In certain applications, the sensor can be omitted from the system.

This device assumes that coal is to be left in the roof and often floor. A pre-determined extraction thickness is calculated to provide the floor horizon.

.2 Pick Force Sensor

The Pick Force Sensor consists of a pick on the face side of the drum, instrumented with a piezo crystal or strain gauge, which produces electrical signals proportional to the force the pick experiences, while cutting through individual bands of varying hardnesses in the strata. The sensor does not directly indicate the drums horizon, but produces a pattern of forces related to the pick's angular position in the drum. This pattern is co-related with a master pattern, representing the correct drum position and the correlation indicates the error in position of the drum within the seam.

This complex method is the only one of two ways currently envisaged of coping with applications where neither roof nor floor stone must be cut and intermediate bands of strata within the seam are irregular or inconsistent. There is still no accurate way of independently surveying sites for possible use of pick force sensors and this method increases the likelihood of successful applications.

The concept of pick force sensing is not new, but the developments in instrumentation, signal processing and intrinsically safe micro-processors have increased the accuracy and reliability of this transducer.

Previous trials were based on trying to identify a distinctive coal rock interface. Errors can arise with this method since if a thin piece of rock is cut, it may break and react as coal.

If the drum is raised rapidly while cutting coal, it may generate a signal that rock has been struck. To overcome these problems, a solution is to take no corrective action until three successive signals confirm rock or coal.

There are two methods of transmitting signals from the sensor to the micro-processor mounted on the shearer. One is to telemeter the signals via a transmitter mounted on the drum to a receiver on the shearer. The alternative is to hard-wire through a slip ring arrangement. The former is preferred.

.3 Recognition

This system relies on the machine automatically storing the adjustments made by the operator during a manual traverse of the face. Machine tilt in both directions and boom angles of the ranging drum are stored and reproduced on subsequent 'automatic' runs. A normal override allows for change in conditions.

.2 Tilt Transducers

There are two tilt transducers required in the system to measure:

- Face Advance Tilt (FAT) angle, i.e., the angle of the machine relative to the seam inclination, in the direction of face advance.
- Along Face Tilt (AFT) angle, i.e., the angle of the seam inclination along the face (used only for monitoring face contour variations).

A tilt transducer consists of a curved, linear potentiometer whose operating slider is fitted to a free moving pendulum. When the assembly is tilted, the pendulum keep its vertical position while the slider moves across the potentiometer by an amount proportional to the angle of tilt.

.3 Roof Height Transducer

The roof follower is a pivoted mechanical arm which is raised and held against the previously cut roof, alongside the cutting drum by hydraulic pressure. A transducer is mounted at the pivot point of the arm and provides an electrical signal proportional to the vertical displacement of the roof follower arm. The complete mechanical arrangement is fixed to the top of the ranging arm. The electrical system provides the system unit with the reference around which all the steering demands are based, i.e., if the roof coal thickness sensor and tilt transducer indicate that the boom requires raising by 15 mm, then this movement is made relative to the roof follower position. All steps in the roof or floor are normally limited to a maximum of +/- 40 mm to maintain optimum conditions.

Trials using 35 GHZ radar and acoustic roof followers have not been successful to date.

.4 Boom Transducer

In a two-pass system, during the floor cut, the roof follower is no longer in contact with the roof and so a second transducer is required. The boom transducer or ranging arm height transducer consists of a potentiometer driven by the ranging arm trunion shaft and measures the angle of the ranging arm relative to the machine body. As the shearer passes on its roof cut with the roof follower held against the roof, the ranging arm angles are taken at intervals and committed to memory. On the return floor cut, these readings are used by the unit, utilizing simple trigonometry, to control the ranging arm movement downwards, the roof follower being powered down. The floor cut is therefore an exact copy of the roof cut and the thickness of extraction is maintained constant.

.5 Machine Movement and Direction Detector

This transducer detects movement of the shearer in each direction. It provides information to allow the machine position, relative to the maingate centre-line, along the face to be monitored. The odometer is a cylindrical steel unit which can be sited in the position where it is most convenient to pick up the machine drive (Figure 4-4).

.6 End of Face Detector

An erroneous along-face-position can be indicated for such reasons as a broken machine haulage chain, cumulative errors as successive shears are taken, or if the odometer unit is turned without the machine being moved. To counteract such happenings, the end of face detector is included in the system. It is in two parts:

- A stainless steel casting, housing a permanent magnet bolted to the conveyor pan furnishings.
- A magnetically-operated switch, housed on the machine underframe in such a manner as to pass within 40 mm of the conveyor-mounted magnet as the machine goes by (Figure 4-5).

As the magnet is passed, the machine mounted switch is operated, signalling to the system unit that the machine is now at a known position. Any errors in the transducer count are then corrected.

.7 Direction Pressure Transducers

Haulage direction sensors are operated by the haulage direction control and indicate the direction of machine travel, right or left to the system unit.

.8 Control Systems

Three manufacturers have advanced automatic steering systems available:

- Anderson Strathclyde - MIDAS which will fit all their shearer range.
- British Jeffrey Diamond - DIAM which will fit SERDS and is being adapted for DERDS.
- Mining Supplies (Longwall) Ltd. - PATHFINDER which will fit available SERDS.

These U.K. based manufacturers based their systems on developments and requirements of British Coal. Manufacturers in U.S.A. such as Joy Technologies Inc., have not yet equipped a shearer with horizon control and have no immediate plans to do so. They have had customers requesting the system, but need to be convinced of the success of gamma-ray or sensitized bit transducers before proceeding to a practical design. They have not done anything with boom angle, machine tilt or face alignment either.

The three systems (Appendix B) operate on the same basic principles (Figure 4-6). The central control unit receives information about the surrounding environment from the transducers and sensors mounted on the machine (see above) and makes decisions on the type of steering action required to maintain optimum mining conditions. Once these decisions have been made, control demands are issued to initiate boom movements. The machine is steered by ranging the boom rather than tilting the underframe. when a deviation in tilt or roof coal thickness is corrected, a step will be put in the roof between the previous and present cuts. The system measures roof coal thickness in the previous cut, together with face advance tilt and determines from these factors the size of step, if any, which is required in the roof to maintain mimimum mining problems.

The step is generally limited to a maximum of 40 mm up or down.

Variations are necessary when full seam extraction is required and no roof coal left.

The basic principal of the three systems leaving roof coal is the use of the Natural Radiation sensor for roof profile. A description of the original MIDAS system can be loosely applied to all three systems.

MIDAS (Machine Information Display and Automation System) was developed by the Headquarters Technical Department (HQTD) of British Coal in conjunction with Salford Electrical Instruments, requires designing into existing machine sections or new sections designed to accommodate it.

.1 Control Unit

The brain of the system is a machine mounted micro-computer (Figure 4-7), which has been specifically designed for the task of automatically guiding the shearer. The unit receives information about the surrounding environment from the transducers and sensors mounted on the machine and makes decisions on the type of steering action required to maintain optimum mining conditions. Once these decisions have been made, control demands are issue to initiate ranging arm movements.

The unit measures 330 x 300 x 100 mm, has a LCD of four lines by 32 characters and it contains three RCA 1802 CPU's (Central Processing Units) each with 32 K of RAM and 32 K of ROM.

.2 Personality Unit

Allows for the wide variety of different mining conditions and machine types which exist throughout the world to be dealt with by one standard control unit (Figure 4-8). Variations particular to a face such as ranging arm length, desired roof coal thickness, haulage type, etc., are entered into the unit memory via the 32 rotary switches on the front panel of the unit. To prevent access by unauthorized personnel, entry to the switch panel is by a security key. Opening the front door during normal operations causes the system to return to commissioning mode, which is used during face installation.

.3 Power Supply Unit

This unit produces three segregated supplies designated IS1, IS2 and IS3. IS1 produces the MIDAS control and personality units and all transducers with the exception of the Machine Movement and Direction Detector (MMADD). IS2 produces 10 V stabilized at 250 mA and is used to power the machine mounted data transmission system. The IS3 power supply produces 5 V at 250 mA and powers the Machine Movement and Direction Detector.

.4 Multiplexer

The multiplexer re-transmits data from the control unit along the trailing cable while monitoring IS segregation. In doing this, the data rate is slowed from the high rate at which MIDAS transmits data to the lower rate required by the transmission line to the surface. Existing installations require an additional multiplexer on the gate end to extract the data from the pilot circuit.

Systems with the natural radiation sensor requires roof coal to be left to enable the system to work. The steering algorithm system is at work successfully in Australia on a AM 500 shearer where the mine required full seam extraction incorporated in an automatic vertical guidance system.

The steering algorithm uses as inputs the roof follower output and the machine angle in line of face advance.

The roof follower control loop (Figure 4-9) uses the hydraulically operated roof follower arm which follows the previous cut roof. Control loop calculations are made every 100 ms. The roof follower transducer produces a voltage proportional to the angle between the roof follower arm and its theoretical zero position, parallel to the ranging arm centre-line. When the signal from the transducer is equivalent to the roof follower reference, the resulting step in roof is zero. In these circumstances, the contact point of the roof follower arm is level with the top pick point on the cutting drum and the machine is said to be "on reference".

If the roof follower arm moves "off reference", the summation produces an error voltage, this being positive for an upward movement of the roof follower arm. The control unit then activates the electro-hydraulic interface and the ranging arm is raised or lowered accordingly to create a step in the roof. Movement of the ranging arm causes the roof follower arm to be compressed or released, this causing the signal from the roof follower transducer to alter. When the summation of the roof follower signal and roof follower reference is again zero, i.e., "on reference" ranging arm movement will cease.

To prevent the control loop from hunting about the reference points, the error voltage output from the summing device is subjected to a dead board circuit, which prevents the control unit from acting on small steering demands of less than ± 10 mm.

However, steering demands in excess of this are acted upon in full, producing equivalent movements of the ranging arm.

Machine angle algorithm, the angle of the cutting drum with respect to the horizontal, in-line of coal face advance, is measured by the face advance tilt transducer. The tilt transducer produces a voltage proportional to machine tilt angle which is relayed to the control unit.

A comparator compares the face advance tilt signal with the seam angle reference entered into the Personality Unit at commissioning. A software conversion factor is applied to machine angle error converting from angular to linear mesurement. The conversion factor is such that one degree of tilt is converted to 16 mm displacement of the face side of the cutting drum.

A machine angle gain factor is set into the Personality Unit at commissioning and sets the system sensitivity such that it is responsive, but not liable to overshoot. The gain factor has a value between 0 and 1, a figure of 0.8 generally being set. The limited machine angle error signal is then tested against the roof step limit.

Steering demand generation, the steering demand requested by the machine angle error signal, is tested against the roof step limit which prevents the control unit from generating a roof step of more than 40 mm for machine angles of up to 4 degrees. In exceptional circumstances when machine angle exceeds 4 degrees, the roof step limit may be increased in proportion to the machine angle, up to maximum step of 65 mm. Large roof steps between successive shears are avoided and any errors are corrected gradually over several passes.

The roof follower signal is compared with the roof follower reference to give the step in roof. This is then compared with the steering demand to give the steering error.

If the steering error is outside the dead board limits, i.e., ± 10 mm corrective steering action, back to the centre of the dead board takes place.

Ranging arm loop control for a machine operating a double pass mining method changes the steering philosophy when the floor cut is made. The ranging arm loop control (Figure 4-10) is implemented depending on haulage direction. During a roof cut, ranging arm height readings are stored in the control unit at each odometer count.

On the return floor cut, these stored ranging arm height values are compared with the desired extraction, less the drum diameter to produce a ranging arm reference signal. This is compared with the preset ranging arm height to produce a steering error. If the steering error is greater than the dead band (± 10 mm), the ranging arm is raised or lowered to reduce the error to zero.

In this way, a constant extraction is maintained throughout the coal face.

For a single pass DERDS, the leading drum algorithm uses the current machine angle in face advance measured with respect to the seam angle and the step in the roof between present and previous machines passes, measured at the drum centre-line. The trailing drum algorithm uses the current machine angle in face advance, measured with respect to seam angle and the step in the roof between present and previous machine passes, measured at the drum centre-line, modified by the extraction from personality minus the drum diameter from personality.

In automatic, both roof followers are activited.

For a double pass DERDS, the leading drum algorithm for the roof cut uses the current machine angle in face advance measured with respect to seam angle and the step in the roof between present and previous machine passes, measured at the drum centre-line.

On the return pass, the leading drum becomes the trailing drum and uses the ranging arm loop control algorithm. The trailing drum, which becomes the leading drum, is controlled by the extraction set during commissioning. The closed loop control system maintains the cutting drum in the desired position. In automatic, only the leading roof follower is activated and only during the roof cut. On the floor cut, both roof followers are down.

.9 Adaptive Automatic System

Eickhoff have developed a micro-processor based system based on a 'recognition' traverse. During this recognition traverse, the machine automatically stores the adjustments made by the operators, i.e., both the longitudinal and traverse inclinations as well as both ranging arm angles. The stored data allow for an automatic traverse during which only the machine travelling speed is selected by the operator. At the same time, the computer ensures that the cutting height of both drums corresponds to that during the recognition traverse and the inclination is automatically corrected. In the case of a change of the geological conditions on the face after advancement of the AFC, the operator can correct the position of the ranging arms by means of umbilical cord control or radio remote control and the stored recognition data are adapted to the actual conditions.

4.4 SHEARER POSITION INDICATION

Three systems are available for shearer position indication.

- Odometer
- Infra-red
- Cotag

The odometer unit is used within the shearer control systems in the U.K. and is also known as Machine Movement and Direction Detector (MMADD).

The odometer, Bretby type, ODI, is a twin micro-switch system which has been adapted (Figure 4-4). The odometer is a self-contained unit driven by the output of the machine haulage to provide its position. The commissioning of the system requires the machine to be moved a measured distance and determine how many counts per metre. This value is programmed into the computer, as is the machine position determined by chock number, multiplied by chock centre distances. Haulage direction switches are incorporated in the direction control shaft housing operated by cams mounted on the direction control shaft.

A face end switch (Figure 4-5), which detects when the shearer reaches the face end, consists of a read switch housed in a brass tube within a stainless steel enclosure. It is operated by a magnet which is fastened to the pan side at the main gate end of the face. Its purpose is to reset the odometer count each time the machine returns to the head end, should a discrepancy occur.

A major disadvantage of this system is the requirement to input information accurately. Any error can be accumulative and a power failure supply to the system can lead to error if the system is not reprogrammed.

The infra-red system was developed by Dowty for shearer initiation of their supports. There are currently three systems in operation at Consol Humphrey (U.S.A), Oak Grove (U.S.A.) and Bagworth (U.K.).

A transmitter unit is mounted on the shearer and a receiver unit is attached to the canopy of each support. The receiver unit is connected together with other support transducers to the chock interface unit. The powered support control centre positioned in the gate end can determine which support is adjacent to the transmitter. The support number together with the direction of travel of the shearer is displayed.

The transmitter unit consists of a medium power infra-red source diode, positioned behind an impact resistant window. The construction of the case allows a transmission over an angle of 120 degrees in the horizontal plane and an angle of 60 degrees in the vertical plane. The unit is intrinsically safe and can be powered from a intrinsically safe DC supply (currently, a rechargeable 12 V IS battery is used for this and a low battery indicator is included on the transmitter).

Advantages of this sytem is that the position calculated by the support control computer is a true position, unlike the odometer type of machine position indicators which rely on initial operator input. The integrity of the system is improved also in that failure of the haulage gear or odometer drives does not give a false position signal.

Gullick currently have a machine sensor system in an advanced stage of development. The system is based on transmitting a modulated infra-red signal from the machine and the machine position sensor mounted on each support comprises a receiver which filters out all other sources of radiation to ensure that the link remains safe.

The Cotag system is designed by Austdac Pty, Ltd., Castle Hill, NSW, Australia.

The operating principle, as tried in an Australian mine, is to position a coded tag on every roof support. An interrogator unit, mounted on the shearer, when aligned with the coded tag, activates a transmitter unit which relates the address of the tag and transmits it to a gate end computer.

The system comprises three units:

- Industrial Coded Tag is a small, robust transponder encapsulated in a rugged polycarbonate case and using frequencies in the induction communications band. It contains a custom microchip which controls its operation and a long life lithium cell to support the memory and to ensure a strong output signal during interrogation. 64 bits are available for data storage (including an opertion 16 security bits) offering 280 x 10^{12} different codes to the user. Each coded tag may be reprogrammed as often as required using the cotag programmer.
- 180 Reading Head is a short range device which may be connected directly to a coder or interrogator. It consists of a combined transmit and receiver aerial encapsulated in a polystyrene case and is supplied with 3 m of feeder cable.
- Cotag Interrogator is a wall mounted unit capable of driving up to 16 short range reading heads or four high performance adaptors. The interrogator validates the coded tag response before formatting its code for transmission as serial data, including relevant tag status and reading head address. The interrogator will accept a number of predefined commands from a host computer allowing considerable flexibility in system operation.

A draw back of the infra-red and cotag systems is that their reliability and the transmission of data can be affected by high moisture contents and dust. This is a particular problem in Australia and the U.S.A. where large volumes of water are used to wash down the faces to meet dust regulations and in those mines which have high humidity.

4.5 SHEARER CONTROLS

The system for machine guidance of shearers has already been described. However, there is still the necessity for a shearer operator to accompany the machine along the face to:

- Take manual control during adverse conditions and at gate ends.
- Adjust cowl position and haulage speed.
- Observe the correct operation of the machine.

Control of the shearer should be such that the operator can be sited in a safe position and at the same time, be able to observe the operations of the machine. In addition, the operator can be placed on the fresh air side of the machine at all times; even during bi-directional working.

A number of control methods have been developed.

- Manual push button stations.
- Umbilical cord.
- Radio.
- Infra-red.

The manual push button stations mounted on the shearer can allow operation of machine speed and direction, arm ranging and cowl movement. They can also give visual indication of motor load, haulage load, machine speed, arm position, machine health condition, status of hollow shaft ventilation and pick face flushing. The disadvantages are that the operator is placed in close proximity to the cutting machine and in bi-directional shearing in an area of potential dust. An end station control unit is illustrated in Figure 4-11 and a control layout in Figure 4-12.

Umbilical cord type control consists of a light weight control consol connected to the machine by a flexible cable. This allows the operator to move away from the machine yet perform the same functions.

Disadvantages relate to damage to the cable and the difficulty in moving the console when using four-leg supports. Umbilical cord control is widely used in mines in Japan, Germany, U.K., Spain and Belgium.

Radio control systems overcome these problems and are suitable for a wide range of applications.

A typical radio control system for a power loader consists of an intrinsically safe transmitter fitted with a rechargeable battery, a receiver mounted on the machine in a FLP enclosure and an external aerial. A coupling coil between the receiver and the aerial forms an IS barrier. VHF and UHF band transmitter frequencies are used, together with frequency modulation to transmit command information in digital form. The system is designed to restrict the operational range to 20 m, although this may be affected by the strata conditions and the proximity of equipment. If the operator is outside the operational range, the machine will be automatically stopped. Early digital systems were subject to interference caused by rotation of the shearer drum, movement of the ranging arms, etc., but this has now been overcome and reliable operation is being achieved.

Details of radio control systems produced by Anderson Strathclyde, Cerchar and Eickhoff are provided in Appendix C.

The infra-red system, developed in the U.S.S.R., overcomes the problem of electromagnetic interference that can occur with apparatus operating at radio frequencies. The infra-red signal is detected by photodetection devices mounted on the machine. The infra-red radio is converted to an electrical signal which, after processing, are supplied to the relay of the control unit. Further details are provided in Appendix D.

4.6 CONDITION MONITORING

Condition monitoring is a method of implementing condition based maintenance, which has superseded planned preventative maintenance as a method of keeping mining equipment working with minimum down time.

The aim of condition based maintenance is to detect a slow deterioration in machine performance and condition long before catastrophic failure occurs. Clearly this must be done while the machinery is working, i.e., during normal shifts, since monitoring machine performance must be done while it is active. This involves monitoring various aspects of the machines condition. A large number of shearers are hydraulically hauled and so most of the monitored parameters are hydraulic, the basic ones being oil levels, temperatures, pressures and flow rates.

Although details vary between machine types, the majority of non-electrical faults are due to low oil levels because of leaks and manifest themselves as noise or heat (due to lack of lubrication) or low pressure or flow rates. Rectification of such mechanical faults typically occupies more than 10% of the machine available time.

The control computer can also be used for performing condition monitoring. However, an electronic computer cannot measure pressures, temperatures or flow rates directly, all it can do is some simple processing of electrical signals. The monitored parameters have to be converted into an electrical signal which the computer can deal with. This task is performed by transducers, which enables the signal to be displayed as pressure on the computer screen.

A schematic of machine control and health monitoring system is shown in Figure 4-13 and an example of the conditions monitored is shown in Figure 4-14 (MIDAS Condition Monitoring).

The following functions are monitored:

- Gearhead Gearbox; the lubricating oil level, temperature and flow rate are monitored in the gearhead gearbox to ensure than adequate lubrication of all bearings and gears is maintained.
- Power Pack; the hydraulic sump oil level and temperature and gear oil temperature are monitored in the power pack. The haulage pressure, auxiliary pressure, priming pressure and suction vacuum are monitored by transducers situated in a transducer housing on the face side of the power pack. The auxiliary oil flow rate and coolant flow rate are also monitored.
- Traction Unit; the oil level and temperature in the traction unit are monitored.
- Motor; the micro-processor based pilot circuit diagnostic unit is contained within the motor switchbox chamber and visible through an FLP window as the switch box door.
- A pilot circuit diagnostic unit tests the machine pilot circuit for short circuit to earth faults and open circuit faults.

Automatic read out can be given by an alpha numeric display on the machine for such parameters as pressure, temperature, current, voltage, etc. (Figure 4-15). These are continuously monitored and will immediately display any abnormalities. A key pad is provided so any particular parameter can be checked at any time. The operating performance of the machine is monitored in terms of electric motor/haulage load, coal thickness, drum position, etc., and displayed on the driver's control panel.

There are monitoring indicators for relay, power supply, hydraulic and speed control monitoring.

Also provided are live line indicators which monitor the 3 phase cores entering the shearer and the shearer 200 volt AC solinoid supply.

Indicators utilizing fibre optics techniques are being used which required no physical electrical connection to the 3 phase lines with obvious safety advantages over a conventional indicator.

Where data transmission is installed, all transducer values are sent to the surface computer and can provide useful management information on machine status and performance. Trend analysis can be performed on transducer signals, which can be displayed in a graphical or tabular numerical format. Machine down time can be reduced by spotting detrimental trends and scheduling maintenance accordingly and data recorded from transducers prior to an unexpected break down may facilitate fault diagnosis and decrease down time.

Condition monitoring is not confined to oil pressures, temperatures and flow rates; anything which can be converted into a suitable electrical signal can be monitored.

The research work has been carried out by British Coal on a "run to destruction" test on a gearbox, while monitoring as many parameters on the box as possible to search for information to predict its failure. Two areas emerged as providing useful information - oil condition and vibration. Most of the others (temperatures, etc.) merely confirmed that failure had occurred.

Oil conditions refers to the contamination of the oil by water and ferrous debris. Water can enter units in several ways, e.g., leaking oil coolers, condensation, strata water seeping in through damaged seals, etc. The effects of even small quantities of water in the oil can be serious. Not only does the water reduce the lubricating ability of the oil and encourage rusting during down time, but water in suction lines can vapourize under the low pressure and cause cavitation of pumps.

Emulsifying oils, which hold water, increase in viscosity when water is entrained. Although these oils may hold up to 8% water in a true emulsion, most manufacturers recommend changing the oil at around 2% water content, since water can have adverse effects on some of the additives in the oil which may tend to separate out. It is the additives in an oil which wear out, not the oil itself and so anything which effects these additives can have a serious effect on the properties of the oil. Experiments have been carried out on a transducer for the control systems to detect water in oil.

Ferrous particles in the oil are an indication that wear is taking place. The size of the particles and rate of production can reveal a great deal about the health of the unit. Wear particles are a natural occurrence, even in perfectly healthy units and can be detected long before catastrophic failure occurs.

The time to take action is when background debris gives way to failure debris, typically characterized by larger particle size and greater quantities. New units often exhibit a fairly high initial rate of debris generation due to bedding in, but this settles down to a constant rate "plateau" throughout the working life of the unit.

Methods have been devised to detect ferrous particles on-line in machine units and when the rate of generation of particles reaches a preset threshold, then indication can be given so that an oil sample can be taken and sent for a full ferrographic analysis. This can often reveal the origin of the particles and differentiate between normal wear and wear preceding failure by examination of the size and shape of particles. In addition to this, the loading conditions which caused the generation of the particles can often by assessed by their appearance. This analysis also extends to different failure modes in ball and roller bearings and fatigure failure in gear teeth and shafts. An on-line debris monitoring transducer can act as an early warning system giving sufficient notice to impending trouble for remedial action to be taken.

The principle of operation of the transducer is that a magnetic head attracts the ferrous particles suspended in the oil flow, circulating from the gearbox sump (Figure 4-16). As these ferrous particles gather on the magnet, changes in the magnetic flux pattern can be directly measured by "Hall Effect" sensors.

The transducer output voltage, proportional to the amount of gather debris, would soon saturate if the wear debris particles were allowed to build up beyond a certain amount. Therefore, self-cleaning is necessary for an unattended transducer. In this transducer design, self-cleaning or "flushing" is achieved by physically moving the magnet away from the brass membrane, separating it from the oil flow and allowing the metal particles to be washed away.

After returning to its original position, the magnet starts gathering debris again. The time required to gather a preset amount of debris would be dependent on the concentration of suspended particles of oil, the more particles in the oil, the shorter would be the time between flushing cycles. In practice, a measure of the time between flushing is inversely proportional to wear debris population in the oil.

For a normal gearbox, a period of two hours between flushing was recorded and with the same gearbox, but with a collapsing bearing, this was reduced to two minutes.

This makes a transducer which is simple and robust for mining machines and yet sensitive enough to give a warning of machine failure, typically up to a week in advance.

4.7 EXPERT SYSTEMS

Expert systems or intelligent knowledge-based systems (IKBS) as they are often termed, have been formally defined as intelligent computer programs that use knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. They are one of the first usable spin-offs from the international research programmes investigating the science of "Artificial Intelligence" which involves such areas as natural language processing, image processing and robotics.

Expert systems are expanding the applications for computers into new areas of problem solving. These areas are those which involve far more than the numerical data processing of earlier computing systems. While the conventional computer programming approach is still valid in many types of problems, it is in the application of computers to new problem fields that they are being surpassed by expert systems.

Expert systems are designed to operate like human experts. The features that are common to most expert systems include:

- They are based on heuristic approaches to problem solving. Facts, rules-of-thumb and relationships are the components of these systems rather than numeric data and algorithms. They can, in fact, manipulate symbolic information and rules more easily than numeric data and algorithms.
- They consult with the user to define and solve a problem. The nature of the consultation varies from problem and depends on the information available and the response of the user to questioning by the system.
- They can explain their reasoning behind any conclusion they have reached, if asked. The reasoning at any stage of consultation can also be obtained and they can usually explain why they are asking a particular question.

- They can function usefully with only partial input data and even when not fully developed. They can also manipulate and handle the sort of uncertain information that is often available when trying to solve real problems.
- Most systems attempt to carry out consultancies and provide explanations or conclusions in a "natural language" format.
- They can be modified easily by non-programming personnel, increasing the flexibility of the system and reducing dependence on trained programming staff.

As an example, an expert system has been developed by British Coal to give expert help and advice for speedy diagnosis and repair of faults in Anderson Strathclyde AM 500 shearers (Figure 4-17).

The AM 500 shearer is a sophisticated machine incorporating complex mechanical, hydraulic and electrical systems. They have been in worldwide use for considerable time, but when break downs do occur, it is essential that the fault is located and the shearer is returned to service in the quickest, most cost effective way. Some collieries have built up useful expertise in fault diagnosis. In fact, there is often a "shearer expert" at the mine. Other collieries are only just introducing these shearers and so do not yet have a resident "expert". They have to rely on handbooks and any training that personnel may have received. When the shearer breaks down, sometimes the fault is obvious, even to the comparative new user, but often it is quite complex and needs logical investigation to find the cause. Even at mines where there is a resident "expert", difficulty may be experienced, i.e., he may be on leave or sick.

The engineer at the face with the faulty shearer can seek help from the computer expert system, which at this stage of development, is located on surface and he can be advised of the most appropriate course of action to take for the symptoms shown.

The program is "symptom-driven"; that is the computer uses what the troubled machine exhibits in terms of its symptoms to estimate the best possible way to find the cause of, and to rectify, the break down. As an example, the basic symptom might be that "the shearer will only haul slowly". The computer then "asks" a series of questions which will be answered by the engineer underground. After each question and reply, the program reconsiders the best course of action and suggests the most appropriate method of attack. Eventually, the most likely cause of the break down will be found and appropriately remedial action advised.

The benefits of quickly and accurately locating a specific faulty item when related to machine down time can be substantial. However, there will always be the odd failure about which the computer "knows nothing"; then it is up the engineers rectifying the fault to let the program developers know so that the symptoms, causes and actions taken can be incorporated into a future issue to help others who may have similar problems. In this way, unusual failures, manufacturer's modifications and other information only occasionally required will be generally available and never overlooked or misplaced.

The program which is designed to run on IBM - XT/AT or the DEC VAX range of computers has been field tested at a number of pits and used at British Coal training centres. A typical print out is shown as Figure 4-18.

The next stage in development of the system will be to link the condition monitoring transducers into the expert system. In this way, a number of answers to the expert system's question will be provided on-line and the speed in which the fault is diagnozed will be enhanced. The development of all electric shearers will ease the task to some degree.

4.8 PLOWS

In Germany, plow faces outnumber shearer faces and generally, operate in seams thinner than 1.9 m.. With the development of a "static plow", a plow sliding steel to steel on a base plate fixed to the face conveyor (Beckmann Klauss 1987) the plow can be steered by tilting the conveyor. In a plow operation, the excavation is of a fixed height and the horizon is determined by the position and angle of the floor picks. Hydraulic jacks fitted to the rear of the face conveyor enable the whole width of the conveyor to be lifted. Westfalia have developed an outrigger steering mechanism as a refinement of horizon control (Figures 4-19 and 4-20). Outriggers are usually set at 3 m to 4.5 m along the conveyor and have allowed some automation of horizon control.

Baseplate Gleithobel plow mining systems can include:

- Plow travel indicator, acoustic start-up signal.
- Control of depth of plowing.
- Monitoring of face alignment and face advance measuring system.
- Electronic plow monitoring system.
- Monitoring of gradient.
- Remote operation of roof supports.

.1 Plow Travel Indicator

The movement of the plow along the face can be controlled from a unit situated in either entry. A digital position indicator such as the unit PM or HWAII K of Bergban-Forschung GmbH can show the position of the plow on the face. For safe automation of travel, the high speed plow must slow down towards the face ends, stop accurately (an accuracy of 10 cm is quoted) and then reverse its run. This automation is achieved by a "wireless" switching device using radio frequency consisting of emitters and receivers. The emitter is attached to the plow body and radiates its energy in one direction.

The two receivers are attached to the spill plates of the conveyor near the drive units and are connected to the main control unit by three core intrinsically safe wiring. The whole electronic circuitry is integrated in the control desk housing.

For position indication, pulses indicating position and direction are transmitted. The pulse transmitter by Gruender und Hoetten is mounted on the plow gear box. It consists of two contactless proximity switches in a sensor housing. For the storage of the actual longwall face data at a particular time, a datum run of the plow is regularly required. The data required applies to the face length and the position of the trip switches and adjustment switches. The datum run is manually controlled and must be repeated before production starts and also after every move over the drive unit stations. The base data is stored for use during the automatic operation.

A cable monitoring system adds to the increased safety of all sources by reporting short circuits or core breakages in a damaged cable.

An analogue indicator of the plow position may be used in addition to further increase operating safety and at the same time, improve the recognition of plow position. Where this is part of a separate data gathering and processing system, this arrangement gives an alternate means of control.

With the Westfalia system, if the power fails, the plow will travel up to 1.5 m depending on inertia, but the operator can only restart the plow when it has come to a complete stop.

.2 Control of Depth of Plowing

If a fixed depth of plowing is maintained throughout the face, a straight face line should be maintained.

The depth control, i.e., the advance can be manually controlled to extend all rams for the same distance. Plow installations can employ either a fixed pressure control or a fixed distance control on the rams.

.1 Fixed Pressure Control

This system ensures the same pressure be applied to each ram. As long as the coal hardness remains the same throughout the face, the system can be satisfactory, but as soon as any harder coal is encountered, the depth of cut will decrease and the face will not remain straight.

.2 Fixed Distance Control

This method ensures that sufficient pressure be applied in the ram to extend to a fixed distance. To achieve this pressure, an auxiliary cylinder with a floating piston is added in each double acting hydraulic advancing arm. The position of the piston in the advancing ram is fixed by adding or extracting a fixed amount of pressurized fluid from and to the auxiliary cylinder. The fixed distance control valve is inter-connected with the master control valve to ensure the fixed advance is achieved. The valves are located at the face ends and are centrally controlled. Peng, S.S. 1984 outlines its advantages as follows:

Advantages of fixed distance control:

- Due to constant plowing depth, the plowing resistance is more uniform, it has less moving resistance for the plow and less chain breakage.
- The power required is much less and more uniform.
- Since the plowing depth is fixed for each advance, the face is always straight.

- With fixed distance control, 65% of the haulage force is used for plowing, where as it is only 25% for the non-fixed distance control.
- There is less conveyor breakdown.

.3 Monitoring of Face Alignment and Face Advance Measuring System

This equipment is similar to that of the shearer operated faces as the position of the conveyor is the basis for face alignment. The Bergbau-Forschung unit AFM uses wire 700 m long. Other units use measuring tapes anchored in the goaf. The rotation of a measuring wheel is transferred to the display and control panel. An example is given of 10 measuring points on a 200 m long face with an interrogation cycle of 10 to 15 seconds. In the Bergbau-Forschung GmbH system, commands for advance or retraction can be remotely given to the hydraulic rams from the central station.

Cerchar tried an experimental device in the Provence Coalfield in 1975. It comprised a face alignment display, plow position indication and automatic face alignment.

The face alignment display reproduces the outline of the coal face as a series of lights on a visual indicator panel. The signal come from perforated tape face advance sensors (described in Section 3-5).

The position of the plow on the face is measured by means of the THR thesiscope. Engagement of the chain drive sprocket cogs is detected by means of a two-way magnetic transducer, then added or subtracted depending on the direction of travel of the plow. The plow position is displayed as a line pan number.

The Provence Coalfield's engineers established that the most effective coal winning technique with a gleithobel was to plow non-stop from one end of the face to the other in order to maintain the face alignment. They observed that in order to achieve such results, it was not necessary to adjust the individual ram pressure, but that uniform hydraulic pressure could be applied to all the rams, provided this pressure was varied in accordance with the face advance in the section in which the plow was located.

An electrohydraulic valve is used for pressure control in this particular system, in which the pressure is proportional to the strength of the control current in the coil of the servo-limiter (Figure 4-21).

The automation device for face alignment delivers this control current which is determined on the basis of the data from the thesiscope and the visual face alignment display unit. Programmed instructions to the rams can be selected at will so as to correlate the face advance in the section being plowed with the appropriate pressure to apply.

.4 Electronic Monitoring of the Plow

Electronic monitoring of the plow is relayed to the control station. Operational status of lower limit (toward chain rupture) and threshold limits for hand cutting - jamming can be set using a computer.

.5 Monitoring of Gradient

Most plows operate on gradients of less than 25 degrees although there are some at over 30 degrees. On gradients over 10 degrees, there is a tendency for the unit to slide down hill. This can be corrected by additional rams being fitted obliquely between the base plate of supports and the conveyor, possibly at 15 m intervals. These rams can be operated remotely.

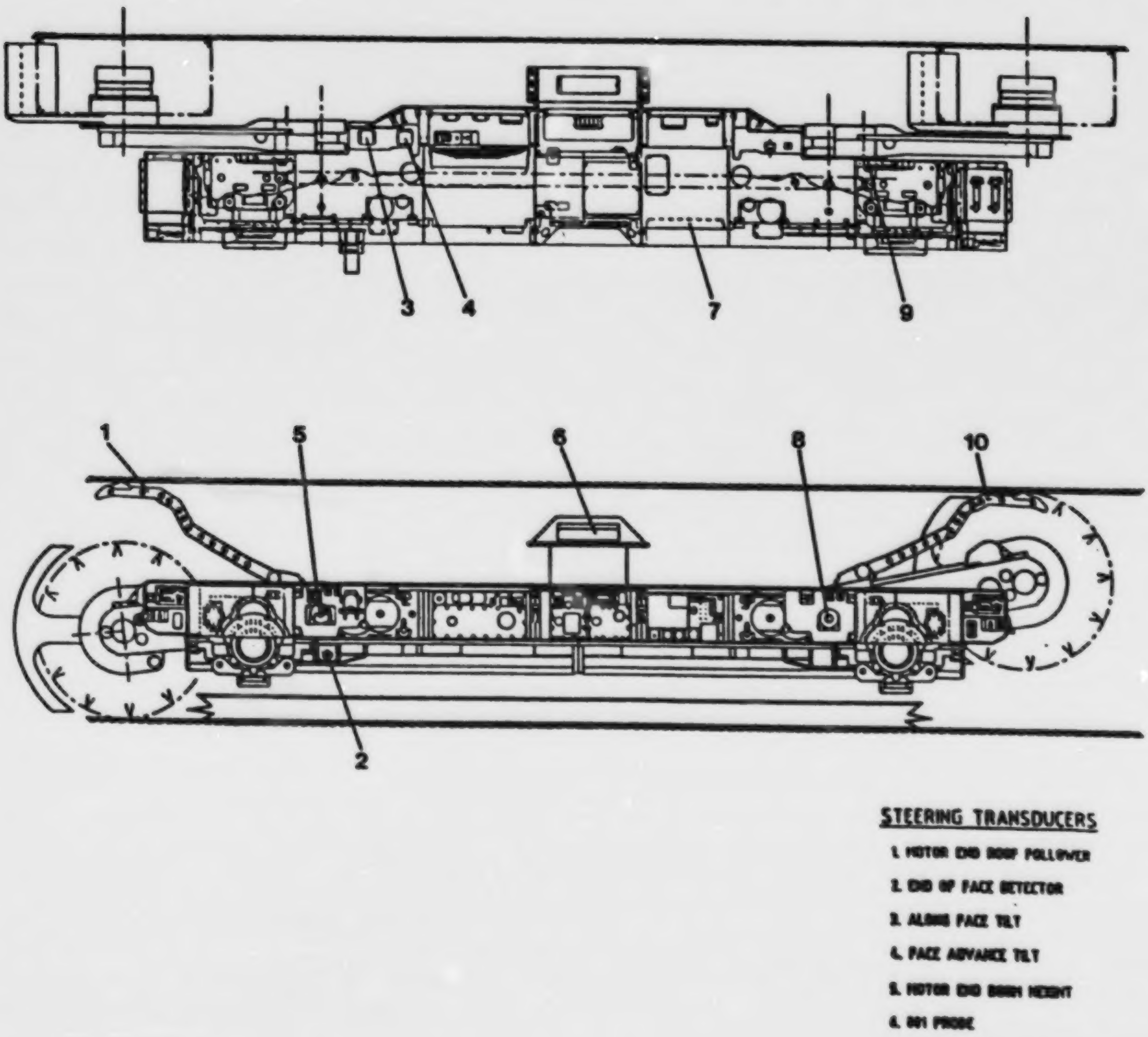
.6 Remote Operation of Roof Supports

The control of face advance and alignment allied to plow position indication can be used to initiate automatic roof support advance through the Westfalia/Siemens Panzermatic E electrohydraulic controls.

FIGURE 4-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

STEERING TRANSDUCERS - DERDS



STEERING TRANSDUCERS

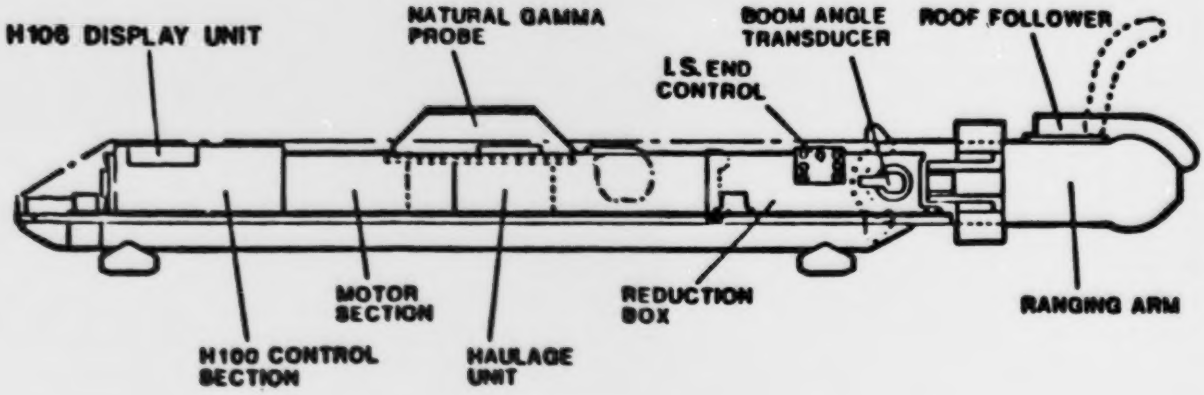
1. MOTOR END ROOF FOLLOWER
2. END OF FACE DETECTOR
3. ALONG FACE TILT
4. FACE ADVANCE TILT
5. MOTOR END BOOM HEIGHT
6. NGI PROBE
7. HAULAGE DIRECTION SENSOR
8. HAULAGE END BOOM HEIGHT
9. MACHINE MOVEMENT AND DIRECTION DETECTOR (MMADD)
10. HAULAGE END ROOF FOLLOWER

Source: Anderson Strathclyde

FIGURE 4-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

STEERING CONTROL EQUIPMENT - SERDS

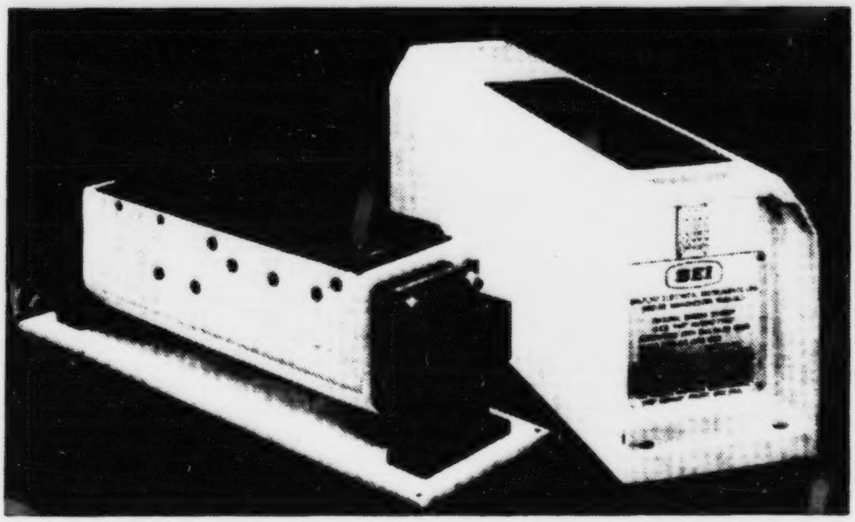

H106 DISPLAY UNIT
NATURAL GAMMA PROBE
BOOM ANGLE TRANSDUCER
ROOF FOLLOWER
I.S. END CONTROL
MOTOR SECTION
REDUCTION BOX
RANGING ARM
H100 CONTROL SECTION
HAULAGE UNIT

Source: B.J.D.

FIGURE 4-3

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING

NATURAL RADIATION SENSOR

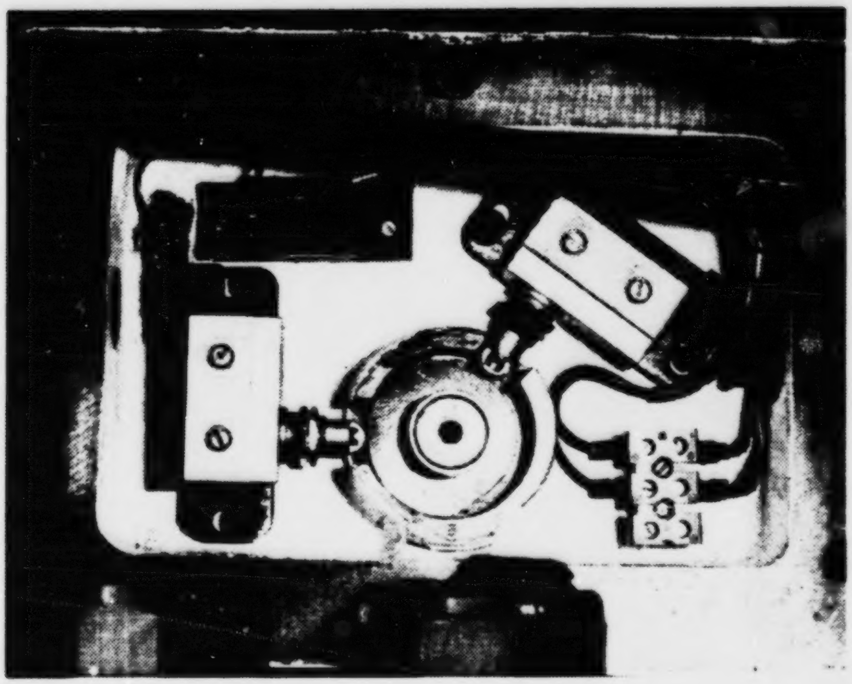


Source: S.E.I.

FIGURE 4-4

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MACHINE MOVEMENT AND DIRECTION DETECTOR



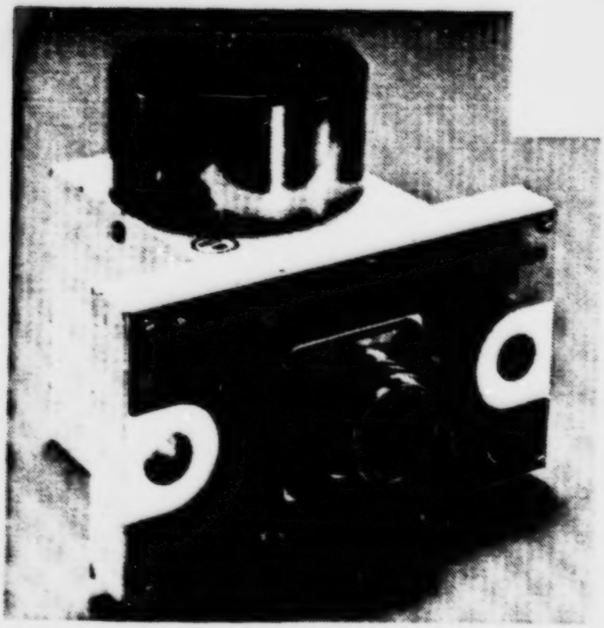
Source: Anderson Strathclyde

AR-122

FIGURE 4-5

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

END OF FACE DETECTOR

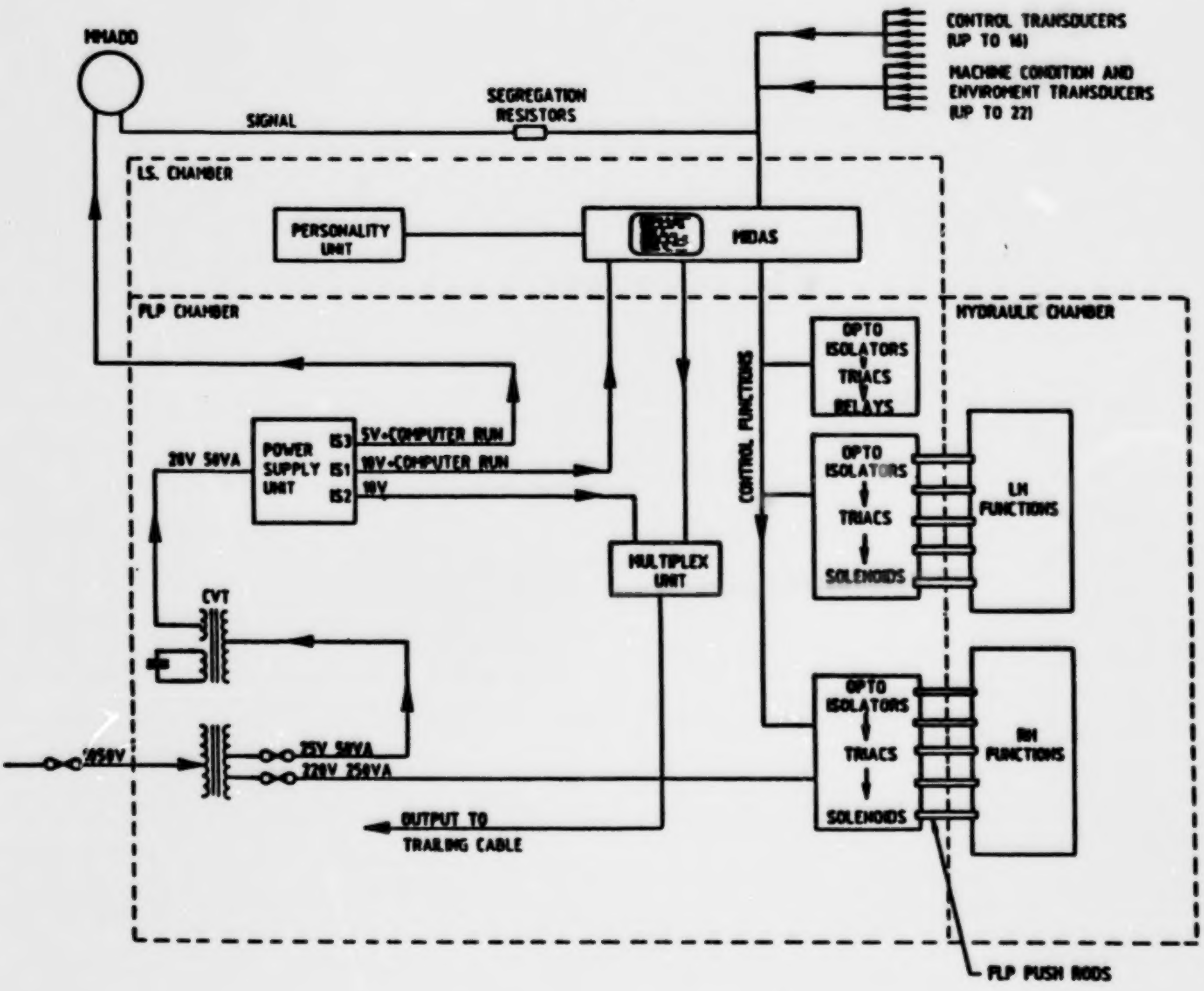


Source: S.E.I.

FIGURE 4-6

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SHEARER CONTROL LAYOUT

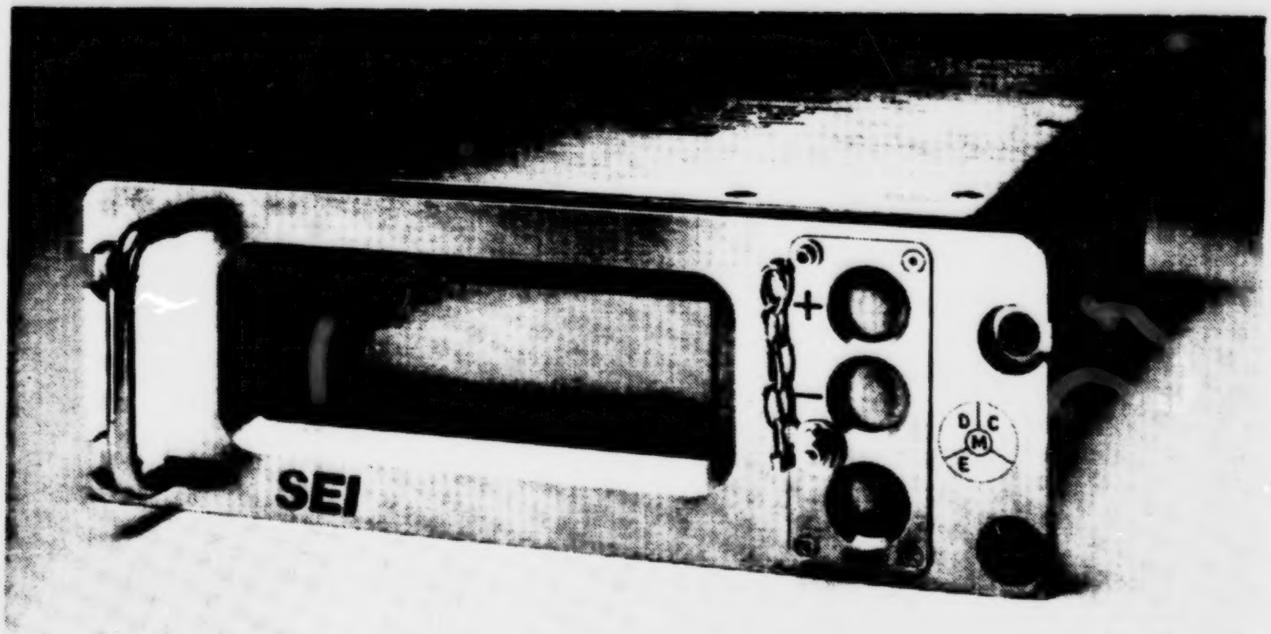

MMADD
SIGNAL
SEGREGATION RESISTORS
CONTROL TRANSDUCERS (UP TO 16)
MACHINE CONDITION AND ENVIROMENT TRANSDUCERS (UP TO 22)
I.S. CHAMBER
PERSONALITY UNIT
MIDAS
FLP CHAMBER
HYDRAULIC CHAMBER
CONTROL FUNCTIONS
OPTO ISOLATORS
TRIACS
RELAYS
POWER SUPPLY UNIT
IS3
IS1
IS2
5V+COMPUTER RUN
18V+COMPUTER RUN
18V
28V 50VA
OPTO ISOLATORS
TRIACS
SOLENOIDS
LH FUNCTIONS
MULTIPLEX UNIT
CVT
OPTO ISOLATORS
TRIACS
SOLENOIDS
RH FUNCTIONS
1050V
25V 50VA
220V 250VA
OUTPUT TO TRAILING CABLE
FLP PUSH RODS

Source: Anderson Strathclyde

FIGURE 4-7

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CONTROL UNIT MRD 90001

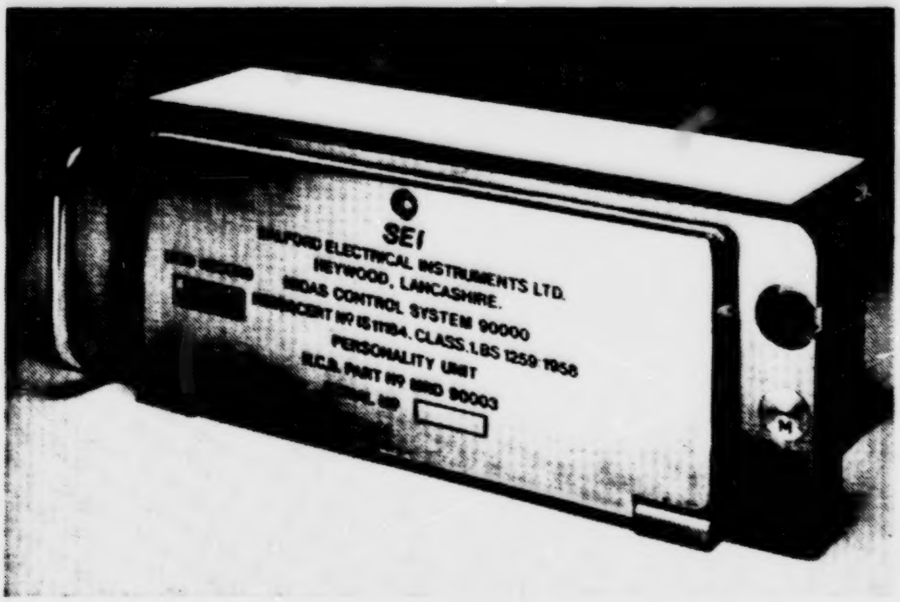


Source: S.E.I.

FIGURE 4-8

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PERSONALITY UNIT

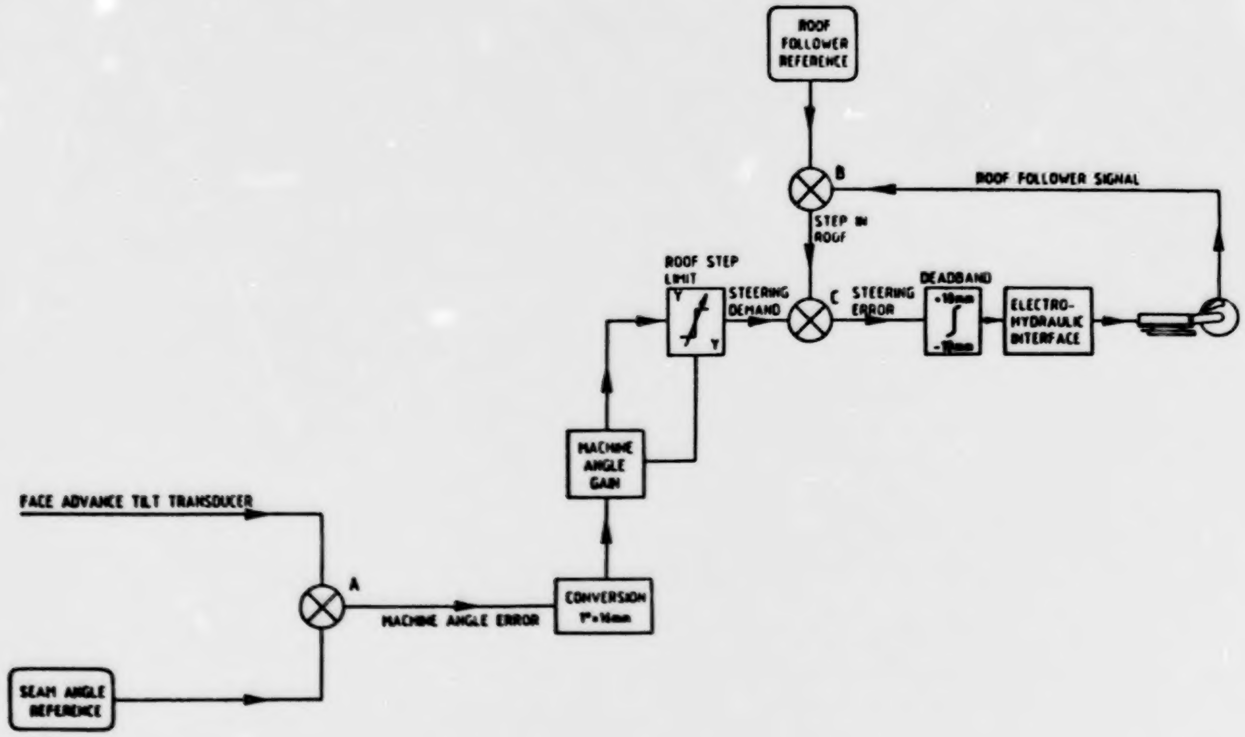

SEI
SALFORD ELECTRICAL INSTRUMENTS LTD.
HEYWOOD, LANCASHIRE.
MIDAS CONTROL SYSTEM 90000
CERT No IS 11184. CLASS.1 BS 1259 1958
PERSONALITY UNIT
N.C.B. PART No MHD 90003
SERIAL No
M

Source: S.E.I.

FIGURE 4-9

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MIDAS CONTROL SYSTEM - STEERING ALGORITHM

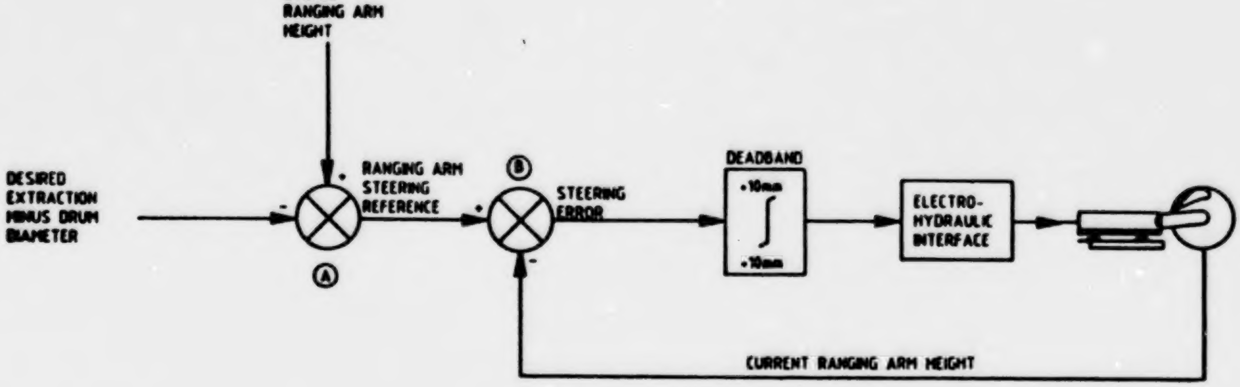

ROOF FOLLOWER REFERENCE
B
ROOF FOLLOWER SIGNAL
STEP IN ROOF
ROOF STEP LIMIT
Y
Y
STEERING DEMAND
C
STEERING ERROR
DEADBAND
+10mm
-10mm
ELECTRO-HYDRAULIC INTERFACE
MACHINE ANGLE GAIN
FACE ADVANCE TILT TRANSDUCER
A
MACHINE ANGLE ERROR
CONVERSION
1° = 16mm
SEAM ANGLE REFERENCE

Source: Anderson Strathclyde

FIGURE 4-10

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MIDAS CONTROL SYSTEM
RANGING ARM LOOP CONTROL - DOUBLE PASS OPERATION

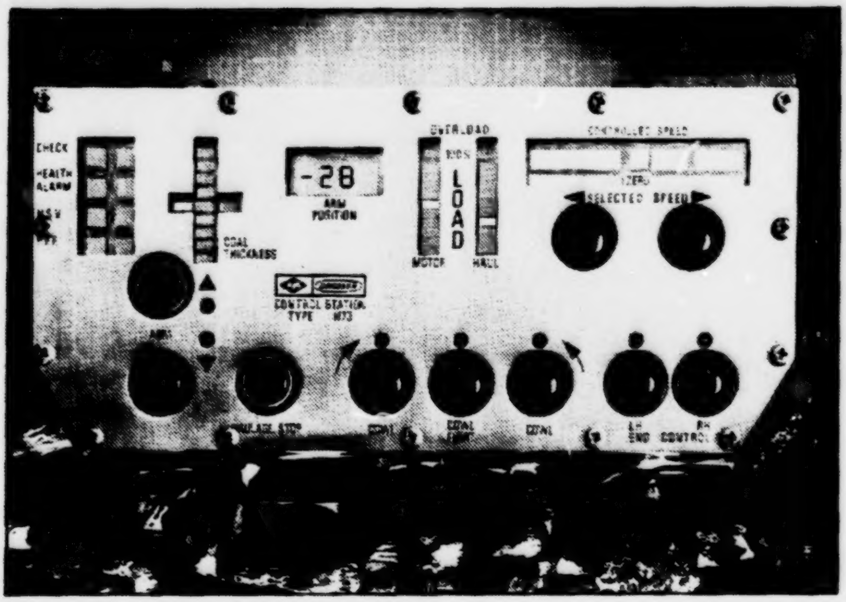

STORED RANGING ARM HEIGHT
DESIRED EXTRACTION MINUS DRUM DIAMETER
-
+
A
RANGING ARM STEERING REFERENCE
B
+
-
STEERING ERROR
DEADBAND
+10mm
+10mm
ELECTRO-HYDRAULIC INTERFACE
CURRENT RANGING ARM HEIGHT

Source: Anderson Strathclyde

FIGURE 4-11

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SHEARER END CONTROL UNIT


CHECK
HEALTH ALARM
-28
ARM POSITION
COAL THICKNESS
CONTROL STATION TYPE M73
OVERLOAD
110%
LOAD
MOTOR
HAUL
CONTROLLED SPEED
ZERO
SELECTED SPEED
ARM
HAULAGE STOP
COAL
COAL
COAL
LH END
RH CONTROL

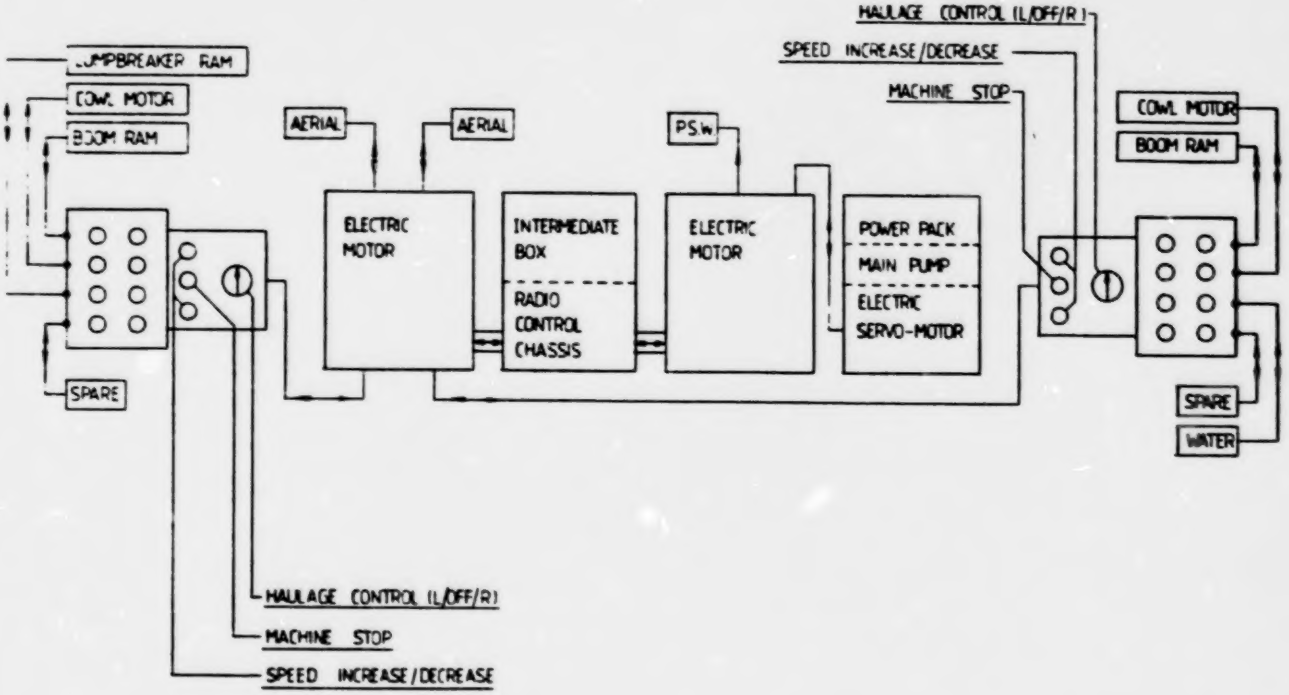
Source: B.J.D./Dresser

AMCL

FIGURE 4-12

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

CONTROL LAYOUT FOR AM.500 RDS

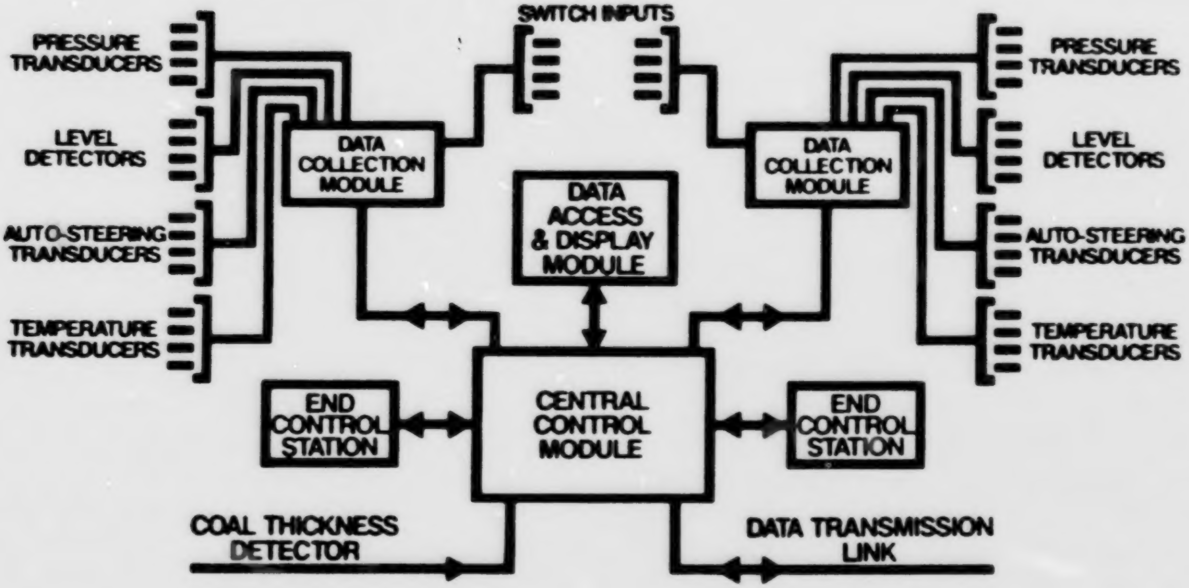

HAULAGE CONTROL (L/OFF/R)
SPEED INCREASE/DECREASE
MACHINE STOP
LUMPBREAKER RAM
COWL MOTOR
BOOM RAM
AERIAL
AERIAL
PS.W
COWL MOTOR
BOOM RAM
ELECTRIC MOTOR
INTERMEDIATE BOX
RADIO CONTROL CHASSIS
ELECTRIC MOTOR
POWER PACK
MAIN PUMP
ELECTRIC SERVO-MOTOR
SPARE
SPARE
WATER
HAULAGE CONTROL (L/OFF/R)
MACHINE STOP
SPEED INCREASE/DECREASE

Source: Anderson Strathclyde

FIGURE 4-13

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MACHINE CONTROL AND HEALTH MONITORING SYSTEM


SWITCH INPUTS
PRESSURE TRANSDUCERS
LEVEL DETECTORS
AUTO-STEERING TRANSDUCERS
TEMPERATURE TRANSDUCERS
DATA COLLECTION MODULE
DATA ACCESS & DISPLAY MODULE
DATA COLLECTION MODULE
PRESSURE TRANSDUCERS
LEVEL DETECTORS
AUTO-STEERING TRANSDUCERS
TEMPERATURE TRANSDUCERS
END CONTROL STATION
CENTRAL CONTROL MODULE
END CONTROL STATION
COAL THICKNESS DETECTOR
DATA TRANSMISSION LINK

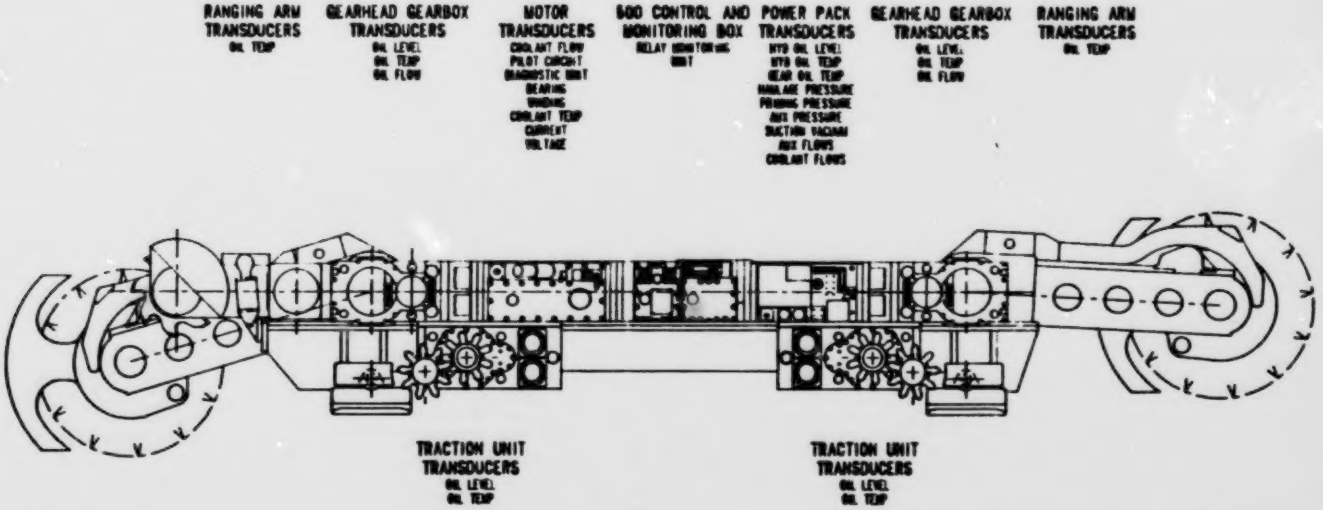
Source: B.J.D./Dresser

AR-122

FIGURE 4-14

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

MIDAS CONDITION MONITORING


RANGING ARM TRANSDUCERS
OIL TEMP
GEARHEAD GEARBOX TRANSDUCERS
OIL LEVEL
OIL TEMP
OIL FLOW
MOTOR TRANSDUCERS
COOLANT FLOW
PILOT CIRCUIT
DIAGNOSTIC UNIT
BEARING
WINDING
COOLANT TEMP
CURRENT
VOLTAGE
BOO CONTROL AND MONITORING BOX
RELAY MONITORING UNIT
POWER PACK TRANSDUCERS
HYD OIL LEVEL
HYD OIL TEMP
GEAR OIL TEMP
HAULAGE PRESSURE
PRIMING PRESSURE
AUX PRESSURE
SUCTION VACUUM
AUX FLOWS
COOLANT FLOWS
GEARHEAD GEARBOX TRANSDUCERS
OIL LEVEL
OIL TEMP
OIL FLOW
RANGING ARM TRANSDUCERS
OIL TEMP
TRACTION UNIT TRANSDUCERS
OIL LEVEL
OIL TEMP
TRACTION UNIT TRANSDUCERS
OIL LEVEL
OIL TEMP

Source: Anderson Strathclyde

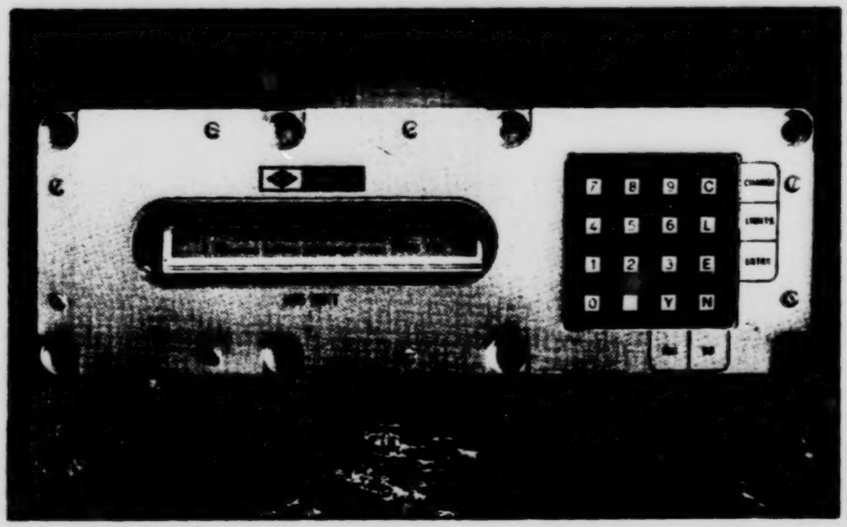
FIGURE 4-15

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

DATA ACCESS AND DISPLAY UNIT

Push button operation of: Machine speed and direction, arm ranging and cowl movement.

Visual indication of: Motor load, haulage load, machine speed, arm position, machine health condition, Hollow Shaft Ventilation (HSV) and Pick Face Flushing (PFF) dust control systems.



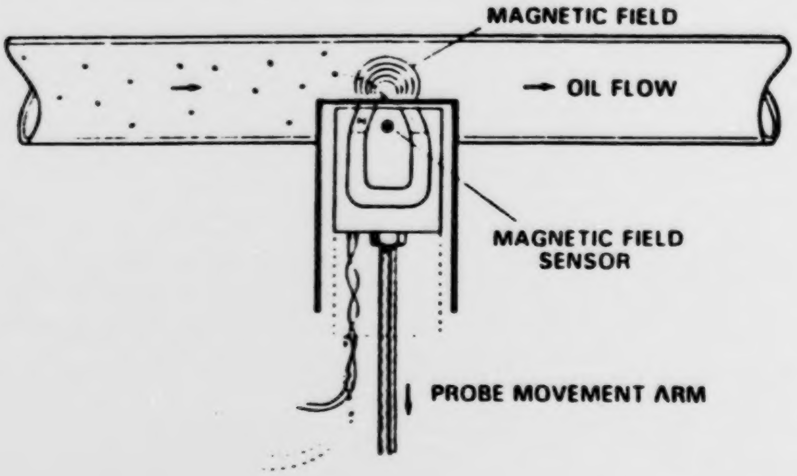
Data Access and Display Unit

Source: B.J.D./Dresser

FIGURE 4-16

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

DEBRIS TRANSDUCER



The specification of an intrinsically safe debris transducer made by Gabriel Microwave Systems Ltd and based on the above principle is listed below.

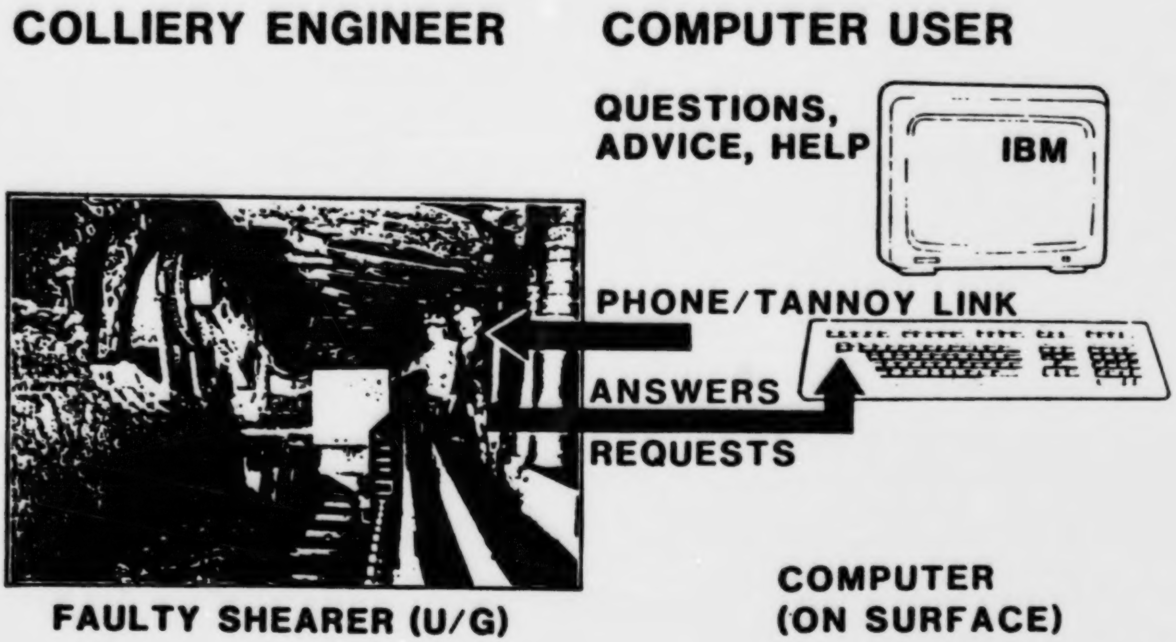
Dimensions	–	130 mm by 140 mm by 70 mm
Output Voltage	--	0.4 V to 2.0 V (BS5754)
Power Supply Voltage	–	12 VDC unregulated
Power Supply Current Consumption	–	20 mA normally rising to 100 mA during flushing
Sensitivity	–	100 mg to 600 mg of ferrous debris for FSD, dependent on application
Operating Temperature range	–	– 55°C to + 125°C
Capture Efficiency	–	30% to 70%, dependent on application

Source: Gabriel

FIGURE 4-17

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

EXPERT SYSTEM CONCEPT

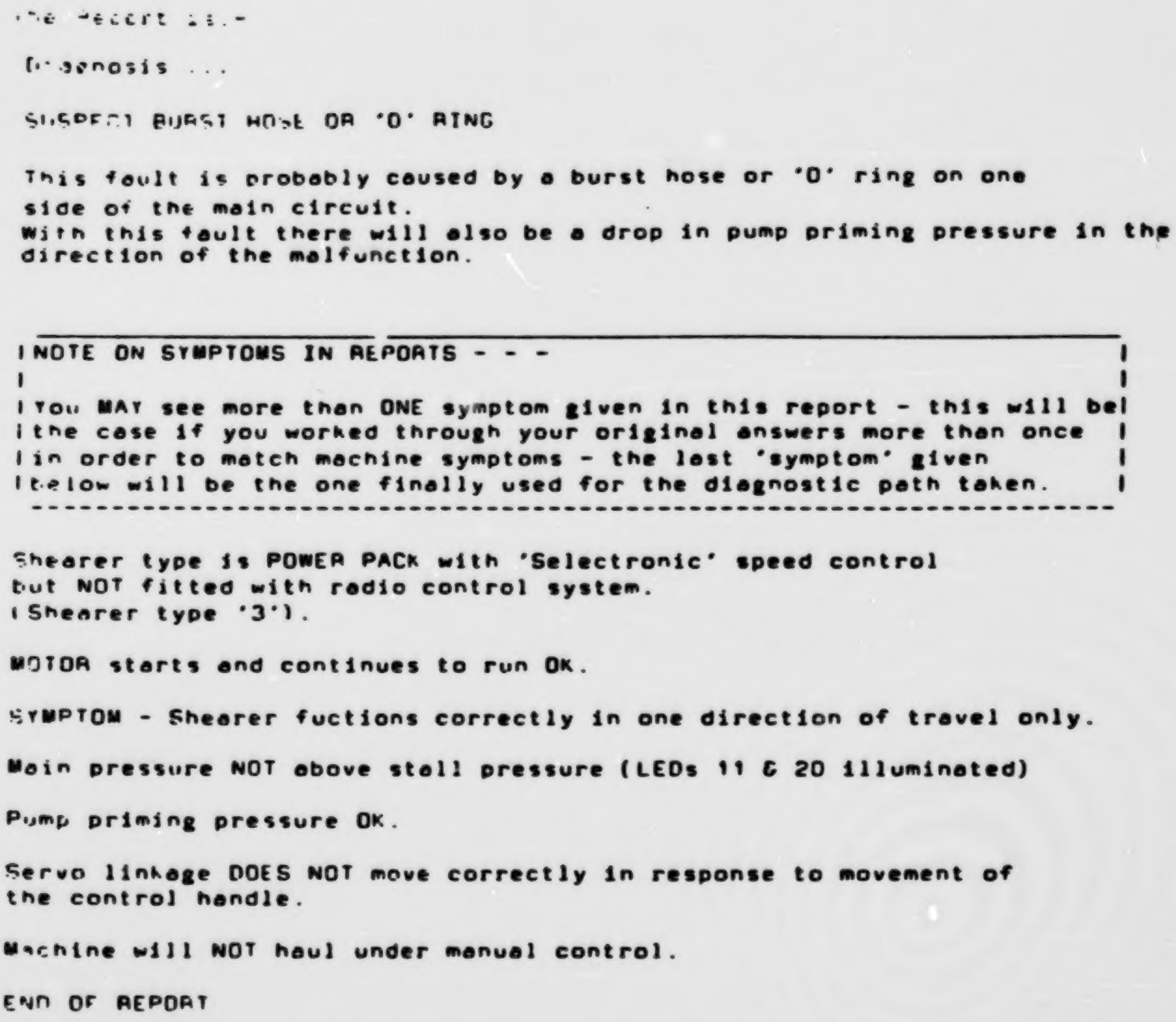

COLLIERY ENGINEER
COMPUTER USER
QUESTIONS, ADVICE, HELP
IBM
PHONE/TANNOY LINK
ANSWERS
REQUESTS
FAULTY SHEARER (U/G)
COMPUTER (ON SURFACE)

Source: British Coal

FIGURE 4-18

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

EXPERT SYSTEM PRINTOUT



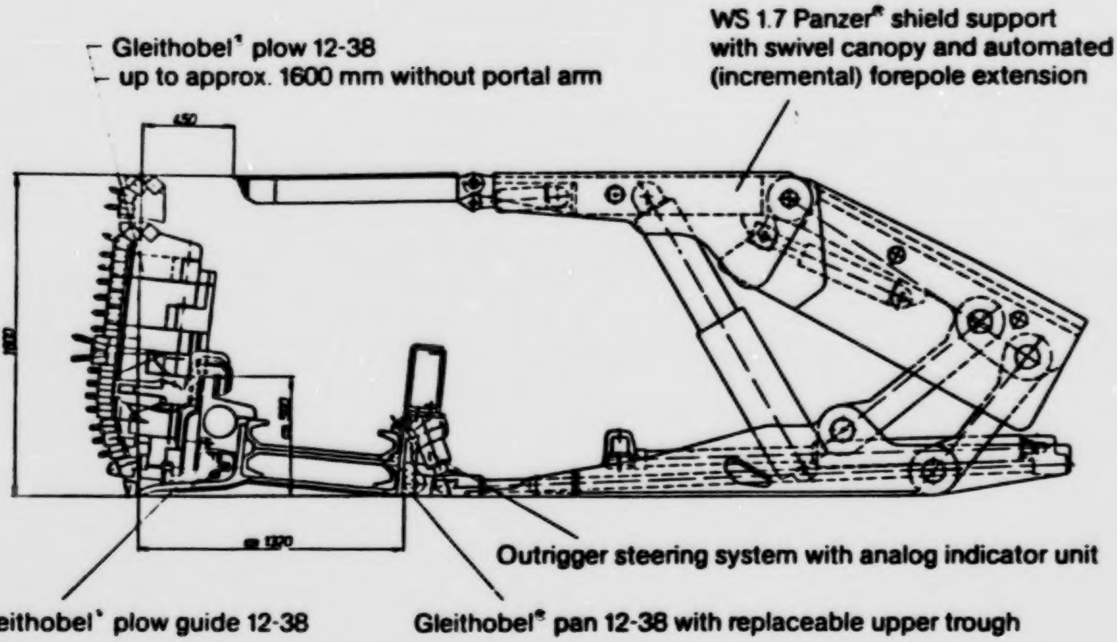
```
The Report is:-

Diagenosis ...

SUSPECT BURST HOSE OR 'O' RING

This fault is probably caused by a burst hose or 'O' ring on one
side of the main circuit.
With this fault there will also be a drop in pump priming pressure in the
direction of the malfunction.

 ________________________________________________________________
|NOTE ON SYMPTOMS IN REPORTS - - -                               |
|                                                                |
|You MAY see more than ONE symptom given in this report - this will be|
|the case if you worked through your original answers more than once |
|in order to match machine symptoms - the last 'symptom' given      |
|below will be the one finally used for the diagnostic path taken.  |
 ----------------------------------------------------------------

Shearer type is POWER PACK with 'Selectronic' speed control
but NOT fitted with radio control system.
(Shearer type '3').

MOTOR starts and continues to run OK.

SYMPTOM - Shearer fuctions correctly in one direction of travel only.

Main pressure NOT above stall pressure (LEDs 11 & 20 illuminated)

Pump priming pressure OK.

Servo linkage DOES NOT move correctly in response to movement of
the control handle.

Machine will NOT haul under manual control.

END OF REPORT
```

Source: Anderson Strathclyde

FIGURE 4-19

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PLOW OUTRIGGER SYSTEM

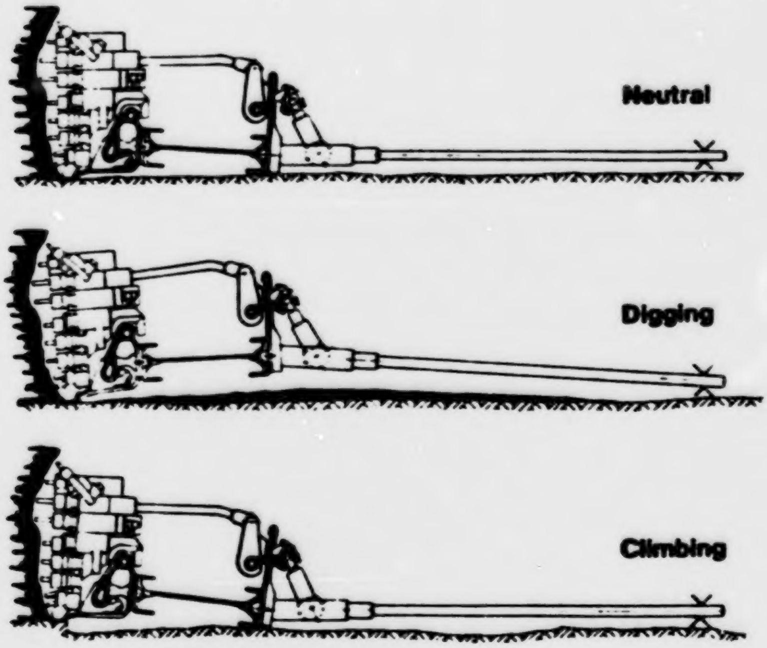

Gleithobel® plow 12-38
up to approx. 1600 mm without portal arm
WS 1.7 Panzer® shield support
with swivel canopy and automated
(incremental) forepole extension
450
ca 1320
Outrigger steering system with analog indicator unit
Gleithobel® plow guide 12-38
Gleithobel® pan 12-38 with replaceable upper trough

Source: Westfalia

FIGURE 4-20

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PLOW OUTRIGGER STEERING SYSTEM

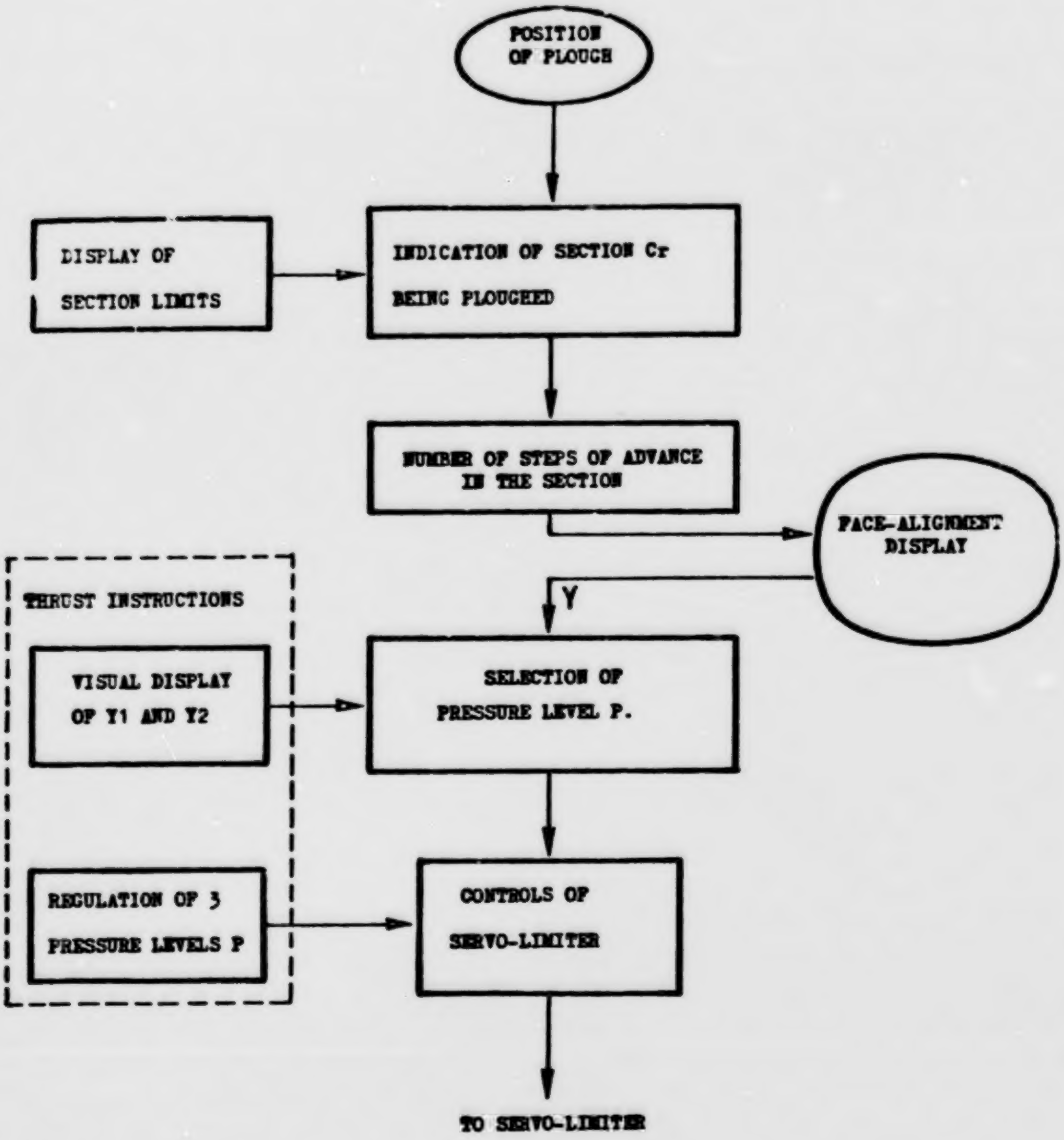

Neutral
Digging
Climbing

Source: Westfalia

FIGURE 4-21

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

AUTOMATIC FACE ALIGNMENT


POSITION OF PLOUGH
DISPLAY OF SECTION LIMITS
INDICATION OF SECTION Cr BEING PLOUGHED
NUMBER OF STEPS OF ADVANCE IN THE SECTION
FACE-ALIGNMENT DISPLAY
Y
THRUST INSTRUCTIONS
VISUAL DISPLAY OF Y1 AND Y2
SELECTION OF PRESSURE LEVEL P.
REGULATION OF 3 PRESSURE LEVELS P
CONTROLS OF SERVO-LIMITER
TO SERVO-LIMITER

Source: Noel

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 5.0 - ARMOURED FACE CONVEYORS

TABLE OF CONTENTS

5.0 ARMOURED FACE CONVEYORS

- .1 INTRODUCTION
- .2 FACE ALIGNMENT
- .3 ROUTINE CONDITION MONITORING
- .4 MOTOR CONTROL

FIGURES

5-1 Coalface Alignment Monitoring System
5-2 Routine Condition Monitoring

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
APPLICATIONS FOR THE SYDNEY COALFIELD

5.0 ARMOURED FACE CONVEYORS

5.1 INTRODUCTION

The armoured face conveyor (AFC) is the third key item of equipment on the coal face. Its purpose is to act as a track for the cutting machine and to clear the material extracted from the face. Two forms of control are required; face alignment and AFC condition monitoring.

5.2 FACE ALIGNMENT

Delays and lost production occurs with AFC's for a number of reasons:

- Misalignment occurs when there are bends in the face. These cause chain stresses which can lead to excessive stretch, chain breakages, starting difficulties, high power consumption, an uneven break line and hence, roof control problems.
- Incorrect heading leads to conveyor creep and delays caused by poor AFC/stage loader delivery.
- Inconsistent web depth can cause localized bends of the face line as well as the inherent reduction in production.

Keeping a straight face line is essential to increasing face lengths where chainless haulage is used and for thinner seams where there is restricted manual control of the face line.

Methods of measurement of face alignment were discussed in Section 3.5.

If the face alignment is known, then corrective action can be taken to return to the straight line required. In general, this is done by fly cuts in which both time and production is lost. One attempt, again by British Coal, to automatically control the face line resulted in the face advance control equipment system (FACE). The system monitors the alignment of the coal face and controls the distance the AFC is required to advance at every fourth support along the face. Each value is calculated to correct any misalignment or incorrect heading, consistent with ensuring the maximum production possible during the time that corrective action is to be taken. If the coal face is straight, then a consistent full web push is ensured throughout the face.

The system (Figure 5-1) is based on the cord advance transducer (CAT). The transducer is fitted to the AFC spill plate every four to six supports. Installed in the control supports is an in chock computer directly coupled to and continuously monitoring the CAT. By this means, the total advance of each control support and hence coal face profile, is known. Each in chock computer is coupled into a coal face communications highway cable which, via a gate interface unit, connects into the gate end control computer.

Data from the "in chock" computer is converted into a coal face profile. The AFC advance required at each control point is then calculated and this information returned to the in chock computer. To advance the AFC, the operator or control signal initiates an activation valve. By monitoring the CAT during the advance, the actuation valve can be closed when the required advance has been obtained.

In order to automatically control AFC creep, the phenomenon has to be monitored and as yet, no suitable transducer has been developed.

5.3 ROUTINE CONDITION MONITORING

A system for AFC routine condition monitoring uses the remote data collection units (Figure 5-2) is used for monitoring support condition. The AFC system is capable of accepting eight inputs of either Analogue or Digital types. They can be sited close to groups of transducers to limit cable runs and provide ease of installation. The system software is arranged so that analysis of information is carried out and displayed within the monitor display unit (MDU).

Each transducer output can be displayed on the MDU screen for monitoring purposes. However, other methods of display are available. The MDU also has the capability to group various transducers, relating to one item of plant or operation, onto one page (display). For example, power, voltage, current and power utilization could be displayed simultaneously.

Trend analysis is available. Information from any nominated transducer can be continuously monitored over a present period of time, usually one or two hours. The transducer output variations are displayed in Bar Graph form against a time base.

Various tests can be carried out by the MDU on the system transducers including:

Voltage Regulation Test: Displaying a graph of the most recent test and a result history to enable prediction of impending supply problems leading to AFC start failure. Results in percent regulation.

Recirculation, No Load Test: Displaying a graph of the most recent test and a result history to enable detection of AFC deterioration due to dirt build up, etc. Results in kW/m.

Coal Load, Machine Performance Test: No graph is displayed for this test, but result history is available. Results in kW/t.

AFC Motor Power Balance: Alarms for imbalance and overload are logged, overload will result in a contact operation which can be used to signal the machine driver to slow down thus preventing AFC stoppages caused by overloading.

All transducers are monitored to detect any values over or under a defined range. All alarms are time logged in the MDU's for future reference and an output available to give an audible warning.

5.4 MOTOR CONTROL

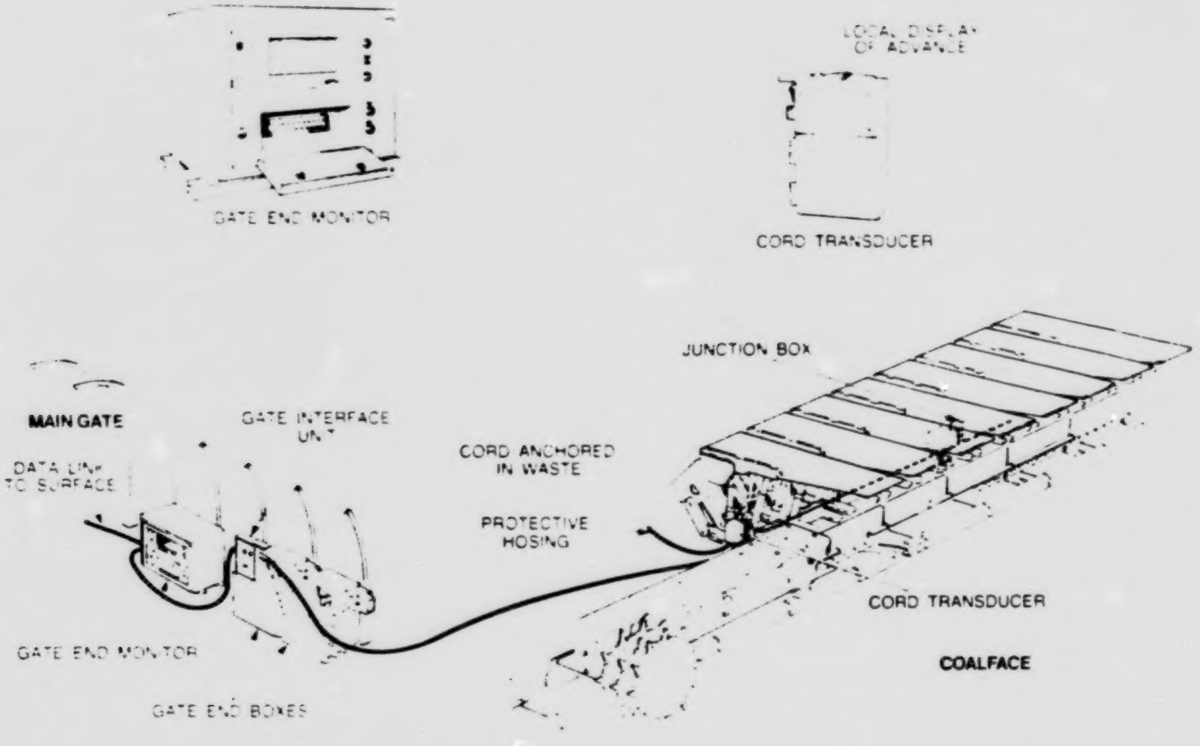
There are coal face conveying installations now using two speed motors rated up to 300 kW at 1500 rpm/150 kW at 750 rpm. When a two speed motor is used, the fluid coupling is eliminated. When starting a two speed motor, designed for constant torque application, the starting torque on the low speed winding can be equal to or greater than that developed by the high speed winding. At the same time, the starting current drawn from the supply would be approximately half that drawn by the high speed winding. This results in a considerable reduction in the voltage drop when starting and gives significant advantages when starting against fully loaded conditions. After the drive has been accelerated to half speed, the half speed winding can then be de-energized to allow the system to operate at its full design speed.

For integration and control purposes, the motor load can be monitored by a transducer in the gate end box. In order to anticipate problems and eliminate break downs, temperature monitoring of conveyor gear boxes can be applied. Automatic and continuous monitoring units give instant warning if any abnormal conditions occur.

FIGURE 5-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

COALFACE ALIGNMENT MONITORING SYSTEM

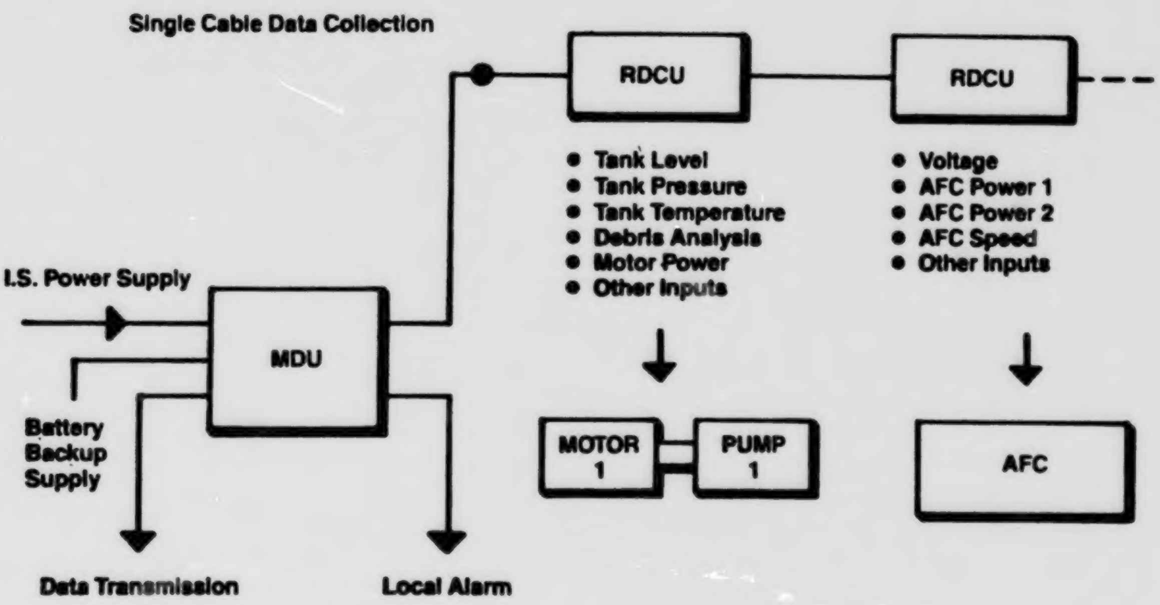

LOCAL DISPLAY OF ADVANCE
GATE END MONITOR
CORD TRANSDUCER
JUNCTION BOX
MAIN GATE
GATE INTERFACE UNIT
DATA LINK TO SURFACE
CORD ANCHORED IN WASTE
PROTECTIVE HOSING
CORD TRANSDUCER
COALFACE
GATE END MONITOR
GATE END BOXES

Source: British Coal

FIGURE 5-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

ROUTINE CONDITION MONITORING


Single Cable Data Collection
RDCU
RDCU
Tank Level
Tank Pressure
Tank Temperature
Debris Analysis
Motor Power
Other Inputs
Voltage
AFC Power 1
AFC Power 2
AFC Speed
Other Inputs
I.S. Power Supply
MDU
Battery Backup Supply
MOTOR 1
PUMP 1
AFC
Data Transmission
Local Alarm

Source: B.J.D.

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 6.0 - INTEGRATED SYSTEMS

TABLE OF CONTENTS

6.0 INTEGRATED SYSTEMS

- .1 INTRODUCTION
- .2 SHEARER INITIATION OF SUPPORT MOVEMENT
- .3 FACE ALIGNMENT
- .4 MULTI-PURPOSE AUTOMATIC CONTROL EQUIPMENT
- .5 FUTURE DEVELOPMENTS
  - .1 Control of Shearer Cutting Speed
  - .2 Gate End Computer Interface
  - .3 Environmental Interface
  - .4 Machine Steering

FIGURES

6-1 Infra-Red Shearer Initiation of Support

6-2 Infra-Red Receiver

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
APPLICATIONS FOR THE SYDNEY COALFIELD

6.0 INTEGRATED SYSTEMS

6.1 INTRODUCTION

A number of individual systems are presently in use at the coal face and more are in development. While systems such as face alignment monitoring, support control and machine guidance systems are self-contained, it can be beneficial to transfer data between them. The advance of automation techniques also require interconnection of systems in order to achieve operating integrity and overall efficiency of operation. Environmental and health monitoring systems will increasingly be linked to control actions, if the goal of a manless automated longwall face is ever to be attained.

This section outlines the limited areas where systems are interconnected at present and discusses some planned developments for the future.

6.2 SHEARER INITIATION OF SUPPORT MOVEMENT

In these systems, the advancement of the roof supports is initiated by the signal associated with the machine position. Different methods have been attempted to measure machine position as described in Section 4.4.

When the odometer or MMADD transducer is used to generate the position of the machine, the signal is transmitted via the trailing cable/gate end box to the roof support system.

Because of the potential dangers inherent with remote/automatic actuation of roof supports, it is vital that the machine position signal is correct and not allowed to initiate unwanted roof support movement. This involves applying fail safe techniques along with checks on the machine position data before it is transmitted to the supports.

The alternative to generating and transmitting the machine position from the machine down the trailing cable to the gate end is to utilize an infra-red link between the shearer and the roof supports. The system, detailed in Section 4.4, consists of an infra-red transmitter mounted on the shearer powered by an IS battery and a receiver mounted on the canopy of the roof supports (Figure 6-1 and 6-2). It is designed to provide an absolute value of machine position and failure of the haulage gear or odometer drive does not give a false position signal.

The machine position is transmitted along with other roof support information to the support control unit which initiates appropriate action. The system can be arranged to ensure that at least one support on the face must detect the machine's transmitted data, otherwise all supports will be safely disabled. Data relative to machine position can also be used to prevent on face push button control operation from occurring too close to the machine.

A refinement being tried by Gullick Dobson in a U.S.A. mine is to scan the infra-red beam from the transmitter to four supports simultaneously. The advantage could be that alternate supports can be initiated when the machine is in motion, i.e,. supports 5 and 7 can be initiated when the shearer is opposite support 9.

6.3 FACE ALIGNMENT

The link between the AFC alignment and roof support systems has been described in Section 5. Future developments will incorporate anti-creep control.

6.4 MUTLI-PURPOSE AUTOMATIC CONTROL EQUIPMENT

To provide some consistency to underground control hardware which can accommodate a range of hardware configurations, British Coal have developed a system called MACE (Multi-purpose Automatic Control Equipment).

MACE is a general purpose, intrinsically safe machine mounted multi-processor facility which has been designed for all types of underground mobile machinery as a standard monitoring and control system. It accommodates various hardware configurations and provides automation for different applications quickly and simply.

The design is aimed to guarantee long life in that it overcomes the risks of computing hardware becoming obsolescent or superseded. This is done by conforming to set standards and being able to accommodate further hardware expansion.

The system has high integrity due to each individual intelligent unit having the capability to operate independently so that the risk of total system failure is minimized.

The hardware design makes use of existing power supplies, transducers and cabling wherever possible. In shearer vertical guidance applications, for example, MACE is supplied from a MIDAS power supply unit and uses the MIDAS Machine Movement and Direction Detector (MMADD).

A fundamental design concept is to fulfill a wide variety of monitoring and control applications without recourse to the redevelopment of basic monitoring software. A basic monitoring system has therefore been developed around the monitoring and communications boards which is independent of the application (Appendix E).

Some examples of underground applications of the system which shows its versatility are:

Shearer Vertical Guidance: SERDS and DERDS all method of mining. Natural radiation and pick force systems.

Horizontal Guidance: A MACE unit could give both face alignment and chock control.

Coal Heading Machines: In-seam miner vertical guidance and control of machine advance.

Tunnelling Machines: Control of profile, line of advance and load.

Face End Machines: Control of profile and load.

Transport Systems: Bunker automation, cement bulk handling, dirt disposal.

6.5 FUTURE DEVELOPMENTS

After present automatic systems become established and have proven reliability, the next step will be to integrate the systems. New systems will be developed to meet needs. Some examples are:

.1 Control of Shearer Cutting Speed

There is benefit from controlling the shearer cutting speed to suit optimum AFC loading conditions. The data gained from AFC power transducers together with advance information, machine speed and position data would be utilized. It may be possible to determine the actual relationship between shearer cutting characteristics and varying AFC loads and hence control machine speed to suit. The ability to control the shearer haulage from the gate while allowing the main motor to run could result in the elimination of AFC stalling conditions.

An extension to this system could be to control face output to match the outbye coal clearance system capacity.

.2 Gate End Computer Interface

Gate end computers can have supporting display and keyboard facilities. A high-speed data transmission link with the surface can be provided for display, hard copy and longer term storage of data. This facility will allow the analysis of system performance and the study of inter-relationships between systems.

Different sources of data would be monitored at one central point and transmitted by a 64 kbaud high speed HDLC link to the surface computer. Different underground systems could be transmitted on the one cable. The gate end computer also acts as the controller for machine initiation of the power supports and allows the system to operate even if the transmission link to the surface is cut.

.3 Environmental Interface

There is a connection between machine cutting speed and environmental conditions such as methane gas concentrations.

At present, if the gas concentration reaches a preset level, then the face production has to be stopped. It will be possible to link the environmental and ventilation conditions to machine cutting speed so that under normal circumstances, the limiting gas concentration is not reached. As gas level increases, the machine would be slowed down and when the gas level drops the machine speed would be increased.

.4 Machine Steering

A number of developments are being considered to enhance the application of machine steering devices including:

Cavity Control: To allow the machine to negotiate a short length of face where the roof is broken, a cavity feature could be specified. This will automatically position the roof follower and boom until the cavity is passed and normal steering is continued.

Bumpless Extraction: At present, the desired extraction is achieved on the first automatic shear. Bumpless extraction is a feature enabling a gradual progression for widely varying extraction to the desired extraction without leaving large steps in the floor.

Coal Section Maximization: Sometimes it is advantageous to have some steering parameters set for areas of the face rather than for the whole face length, for example where the seam height varies along the face. By allowing the extracted height to be varied, accordingly, seam recovery can be optimized.

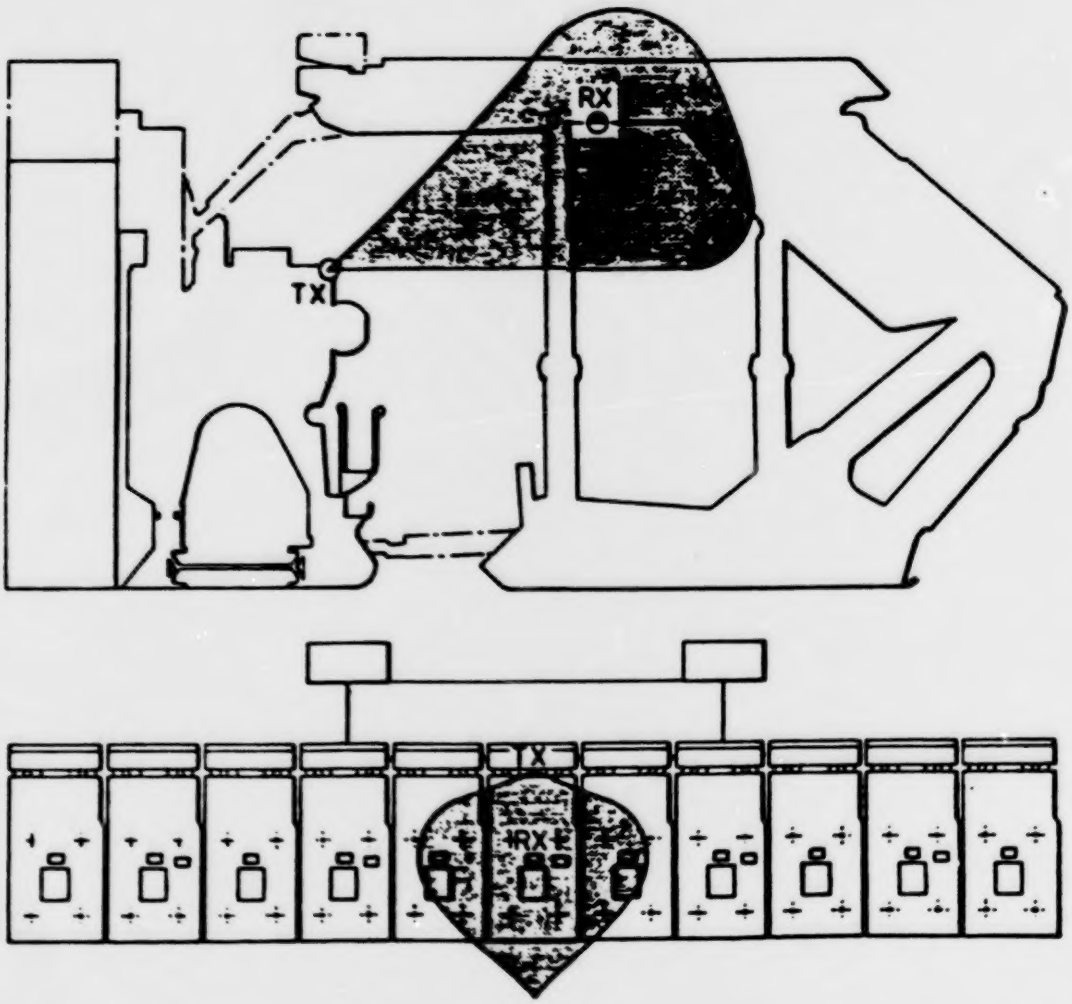
There is no doubt that the operation of longwall faces will become increasingly automated and eventually be controlled from the gate end or even the surface.

However, in the foreseeable future, due to the variable geologic conditions encountered in any coal mine, there will be a requirement for operators to be present on the coal face. Automation and remote control will make systems more productive and safer, but will not in the near term, completely eliminate the human factor.

FIGURE 6-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

INFRA-RED SHEARER INITIATION OF SUPPORT

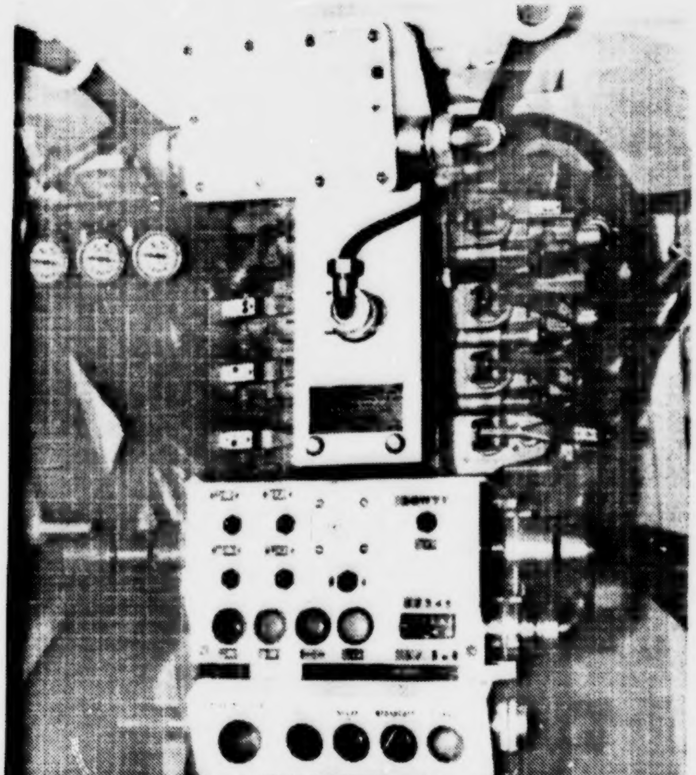


Source: Dowty

FIGURE 6-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

INFRA-RED RECEIVER



Source: Dowty

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 7.0 - BENEFITS

TABLE OF CONTENTS

7.0 BENEFITS

- .1 INTRODUCTION
- .2 ROOF SUPPORTS
  - .1 Advantages
    - .1 Flexibility
    - .2 Speed of Operation
    - .3 Improved Roof Control
    - .4 Improved Web Alignment
    - .5 Simplicity of Operation
    - .6 Safety
    - .7 Reliability
    - .8 Maintenance
  - .2 Disadvantages
    - .1 Cost
    - .2 Replacement
- .3 MACHINE CONTROL SYSTEMS
  - .1 Advantages
    - .1 Improved Horizon Control
    - .2 Increased Production
    - .3 Increased Seam Recovery
    - .4 Improved Coal Quality
    - .5 Decreased Maintenance
    - .6 Safety
    - .7 Financial
  - .2 Disadvantages
    - .1 Cost
    - .2 Reliability
    - .3 Application
    - .4 Cutting Horizon

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 7.0 - BENEFITS

TABLE OF CONTENTS (Continued)

.4 RADIO CONTROL SYSTEMS
    .1 Advantages
        .1 Safety
    .2 Disadvantages
.5 AFC CONTROL
.6 CONDITION MONITORING

FIGURES

7-1 Shearer and Miner Speeds
7-2 Extraction Sections

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

7.0 BENEFITS

7.1 INTRODUCTION

Automation and remote control systems should be beneficial to the mine operator in both overall economic and safety terms otherwise his investment would be wasted. For this reason, there is a reluctance in part of the U.S.A. where mining conditions are generally good and productivity high to pursue automation with any enthusiasm. Conversely, where there are clear advantages to automatic and remote control, then U.S.A. and Australian mines are in the forefront of application. This section discusses the merits and demerits of the systems described.

7.2 ROOF SUPPORTS

The use of electrohydraulic valves integrated with gate and microprocessor control provides a number of benefits.

.1 Advantages

.1 Flexibility

Once the system is installed, modification to software will allow many variation in support operation. Bi-directional remote control is available on either one-web back or immediate foward support systems.

Adjacent, batch, sequence or manual control can be programmed. Signals from other systems can be utilized to initiate the support advance.

.2 Speed of Operation

This is dictated by the hydraulic response to the system. Positive setting continues for 15 seconds after the advance is complete. The next support can therefore be advanced while the previous unit continues to pump pressure. The sequence is not delayed due to system pressure drops. The reduction in cycle time from around 15 seconds to 8 seconds will allow the machine cutting speed to be increased. If the machine speed exceeds the maximum advance rate possible, advancing every support behind the machine would be impractical. The system will then allow alternate rams to be activated.

.3 Improved Roof Control

A condition of operation is that before a support can be advanced, both adjacent supports must be set to the roof. This, coupled with automatic positive settling, ensures total roof control throughout the face.

.4 Improved Web Alignment

All supports advance sequentially. Conveyor pullback is minimized and progressive snaking eliminates system pressure drops associated with bank push systems.

.5 Simplicity of Operation

The roof support operator is fully informed on the progress of the advancing supports (remote).

Information on the set/lowered condition of each support is available and corrected accordingly. The adjacent control is independent of the automatic and semi-automatic systems.

.6 Safety

Safety of the workforce is improved because of the following features:

- A minimum number of operators required in the working area.
- Operators provided with both audible and visible indications of support movement.
- Failsafe emergency stops on every unit. Any stop button will stop all support movement.
- Operators can be stationed on "clean" side of machine.
- Control system is intrinsically safe. Total system demand is only 12 V 0.5 A. No special requirements are necessary for operation or maintenance.
- Control system is immune from noise and designed to fail-safe. Ghost operation is not possible, since only one support at a time is initiated.

.7 Reliability

Reliability of support performance is improved because:

- The only moving parts in the system are the solenoid/motorized valves and two pressure switches.
- System components are minimized, particularly interchock hoses.
- Interchock cables are of a high quality, double wire braid hose terminated in sealed staple fitting connectors.

- Control unit is fully sealed to resist immersion in water, also an immunity to shock and vibration.
- Monitoring and display of leg pressures allow early identification of any malfunction.

.8 Maintenance

Experience has shown that maintenance of electrohydraulic computer based systems is low and can be based on unit exchange. All control electronics are usually contained in one unit and therefore down time is minimized. Faults are readily identified by the inbuilt condition monitoring system and displayed on LCD's or monitors. Training of operators and maintenance personnel for underground unit replacements is relatively easy.

.2 Disadvantages

Disadvantages of roof control systems include:

.1 Cost

The cost benefit to the customer must be closely examined. If he is purchasing a system as new or retrofitting an existing system, the decrease in support cycle time from 15 seconds to 8 seconds must be justified in increased productivity.

.2 Replacement

A manufacturer suggests that one support unit a month, on a 100 support face, can be expected to need maintenance. It must be remembered that these systems contain sensitive electronics and are in hostile environment.

The disadvantage relates to cost. Maintenance is relatively simple. The use of this system reduces manpower necessary on the face. It is therefore necessary for the machinery to operate to its optimum. One possible problem can be the failure of the ram plate to clean up in front of the AFC. With this problem, if the AFC does not advance, the sequence of supports stops or the AFC rises above the true floor.

7.3 MACHINE CONTROL SYSTEMS

.1 Advantages

The advantages of an automatic machine guidance systems include:

.1 Improved Horizon Control

Experience has shown that a vertical guidance system using natural gamma radiation results in more consistent floor and roof horizons which in turn, a lead to improved strata control, better machine performance, a reduction in airborne dust due to cutting in coal, less dilution and improved quality of output.

Steering a manually driven shearer machine depends entirely on the skill of the operators. He controls the cutting horizon by watching the cutting drum which can be hidden by the machine, cowls and AFC and by the coal and water. Often, there are no clear markers in the seam and the operator relies on cuttings colour, sounds and vibration. The result can be poor steering, unwanted dirt from floor or roof, excessive steps in the floor and roof which in turn give poor roof control, delays and loss of web depth. Use of horizon control system have been demonstrated to overcome these problems.

The systems control the rate of steering between successive shears which eliminates excessive steps in the roof and floor.

.2 Increased Production

Production increases from a given seam because of the increased average web depth achieved. Where coal is left in the roof, the thickness can be more accurately controlled and increase in mining section of 10 - 30 cm can be achieved. Improved roof control and absence of large steps reduce delays.

For thinner seams, the production can be restricted by the speed that the operator can travel along the face (Figure 7-1). Full automation will remove this restriction.

.3 Increased Seam Recovery

Experience has demonstrated that shearer operators are unable to accurately control the correct cutting horizon of the machine and as a result, leave more coal in the roof than may be required for roof control. This unmined coal represents a significant loss of output and waste of reserves.

.4 Improved Coal Quality

Poor steering control leads to excessive dilution of the run-of-mine coal due to unintentional cutting of floor and roof. The poor roof control resulting from steps adds to dilution. In the right conditions, improvements in selective mining can be practised.

The benefits of steering control were demonstrated in a field trial at Askern Colliery. Using the DIAM system in place of manual control led to less inferior coal being cut (Figure 7-2).

The use of autosteering was calculated to result in an extra 35 tonnes of coal per strip which over the 1310 strips cut during the life of the face, gave additional output of 45850 tonnes. With cleaner mining sections, the costs of preparation and waste disposal are reduced.

.5 Decreased Maintenance

Where the material cut inadvertantly is hard, then improved horizon control leads to lower cutter pick wear and reduced machine stress. Automatic guidance systems such as MIDAS have proved reliable in operation. When rare faults do occur, the task of changing the faulty units is simple and does not demand high technical knowledge from the maintenance crew.

.6 Safety

The use of automatic guidance systems eliminate the need for an operator for the trailing drum and hence reduces the number of men exposed to the dangers of a longwall face. The absence of large steps in the face means that the supports and AFC can be reliably advanced and improving roof control. Where a constant coal beam is left in the roof, this also improves roof conditions and hence worker safety.

Without a guidance system, the operator will have to manually control the machine. Where four-leg supports are in place, his steering actions are interrupted at every support leg when he takes his hand off the valve handles. This interrupted work attitude can lead to safety problems such as tripping. Without having to manually control steering, the operator is free to ensure that the operating and safety conditons for the system are optimized.

Indications from working faces are that lower and more stable emission of methane into the general body of air takes place and that airborne dust levels are generally reduced. The risk of cutting floor is reduced and hence risk of incendive sparking from any sandstones present.

.7 Financial

The most accurate calculation of the financial benefits of automatic steering was made on a comparison of two virtually identical faces at Wath Colliery. The faces were worked consecutively 400 m apart in the same area of reserves. The same face equipment was used with the exception that on one face, automatic shearer steering was incorporated.

The face fitted with steering was worked out with 75% of the face man shifts and only 70% of the machine shifts previously needed, resulting in a 33% improvement in face productivity to 20 tonnes/man shift. Material costs were lowered by 25% and face delays significantly reduced, with delays from timbering the roof being almost entirely eliminated.

The capital cost of approximately $400,000 for the guidance system used was retrieved in the first 40 working days of the 10 month panel life.

.2 Disadvantages

Disadvantages of automatic guidance systems include:

.1 Cost

The cost of the system can be substantial and should not be invested unless compensatory benefits are obtained in the form of increased output or productivity and better safety.

.2 Reliability

The gamma ray sensor requires a clear interface between coal and roof rock and also a tenfold higher natural gamma emission from the roof material than from the coal. The sensor range is limited to 45 cm of coal, which can be too little under certain scenarios. The location of the sensor is some distance from the drum and so the roof thickness data information must be stored until the drum arrives at the relevant location.

Pick force sensors can give false readings when cutting brittle and thin rock partings or when the drum is being raised or lowered at any speed. They rely on complex pattern correlation techniques to determine the drum position within the seam and in some cases, a recognizable pattern may not be evident.

.3 Application

Present systems may only be suitable for approximately 50% of faces on a continuous basis. Manual steering is required when there are roof difficulties, through faults, where there is no clear roof/coal interface and where the roof material has low gamma-ray emissions.

.4 Cutting Horizon

The natural gamma sensor requires that roof coal be left. Leaving roof coal to form a beam is common practice in the soft roof conditons encountered in Europe. However, where roof conditions allow the coal/rock interface to be used as the roof, then the gamma-ray sensor is inappropriate as its use would result in lost production and productivity.

If a rock roof is used with pick force or adaptive control systems, then there remains the danger of incendive sparking from any sandstones or limestones in the roof.

Sandstones sometimes have low gamma emission rates so that if sandstone channels approach the seam, the gamma-ray detection does not record a roof interface and the risk of cutter picks striking the sandstones occurs.

7.4 RADIO CONTROL SYSTEMS

.1 Advantages

.1 Safety

Radio control provides a fail safe method of remotely controlling the face machine. The operator has greater freedom of movement than with on machine controls or umbilical cord controls (which have to be released every leg of four-leg supports).

The operator is able to stand up to 20 m from the cutting machine away from newly exposed roof surfaces.

.2 Disadvantages

The operator cannot see the cutting horizon of the cutters, particularly the trailing drum.

7.5 AFC CONTROL

The benefits of automatic AFC advance include:

- Maintenance of Straight Face Line: This leads to improved machine running time and increased production.
- Roof conditions improve due to straight breakline.
- AFC load is minimized.
- Reduced requirement for manual face surveys.
- With infra-red and cotag initiation systems, there is a positive location of the machine.

The disadvantages of the systems at present used include:

- Infra-red and the cotag system can be unreliable in conditions of high humidity and dust. These cause disruption to the infra-red and radio waves and can contaminate the system units.
- The odometer unit does not give a positive position indication of the machine. The integrity of the system, while containing checks, can be jeopardized by failure of the haulage gear or odometer drive.
- Manufacturers of roof supports systems will claim that 95% of installations do not need AFC alignment systems and that misalignment is only due to the nature of the face pushing technique. As long as the ram advancing supports extends its correct distance, then advancement of the AFC will keep the faceline straight. They claim the additional control complexity is not justified.

7.6 CONDITION MONITORING

The advantages of installing condition monitoring include:

Information: The collection of data on the condition of monitored parameters such as oil levels, temperatures, pressures, flow rates and electrical conditions allows condition based maintenance to be implemented. The aim is to detect a slow deterioration in machine performance and condition long before catastrophic failure occurs and to correct such defects. On a typical face in Europe, 540 minutes per week can be lost due to power loader mechanical delays. Condition monitoring can save some of these delays with significant financial benefits in terms of increased output.

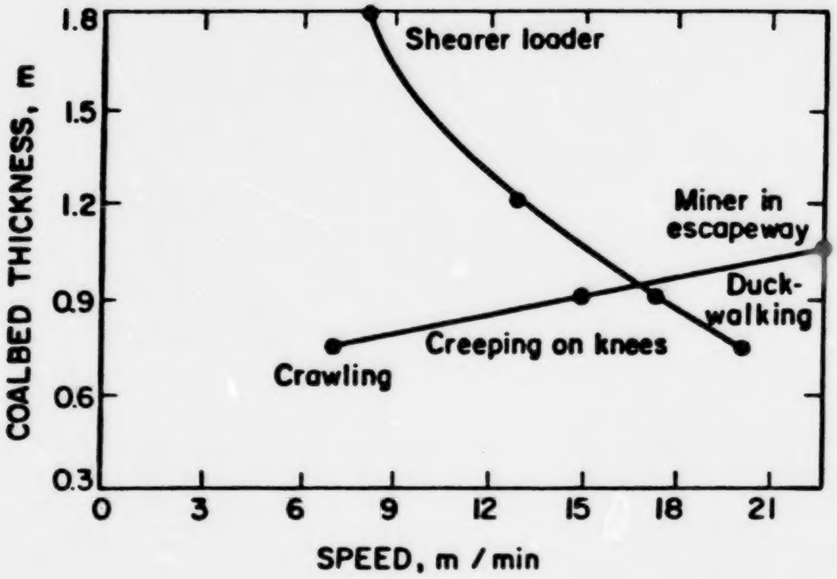
The data storage facilities of a computer based system allows trend analysis to be undertaken and provides management with information on machine status and performance. The data can be used for fault diagnosis and decrease chance of repeat breakdowns.

The main disadvantage apart from cost is that a great deal of information is generated which in itself, does not improve efficiency. It is the action taken as a result of the information provided that is important.

FIGURE 7-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SHEARER AND MINER SPEEDS



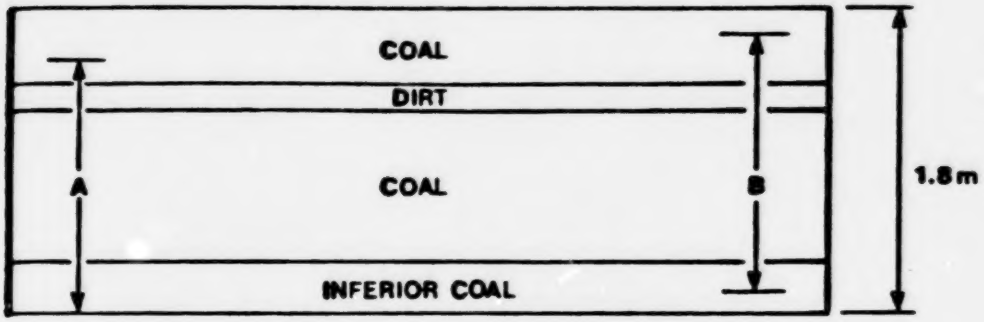
Shearer speed required to produce 1000 tonnes per hour and miner escapeway travel speed as a function of coalbed thickness.

Source: Westfalia

FIGURE 7-2

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

EXTRACTION SECTIONS


COAL
DIRT
COAL
INFERIOR COAL
A
B
1.8m

Geological section of extraction
Warren House 53's face

A – Extraction before DIAM
B – Extraction after DIAM

Source: British Coal

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 8.0 - SYDNEY COALFIELD MINING OPERATIONS

TABLE OF CONTENTS

8.0 SYDNEY COALFIELD MINING OPERATIONS

- .1 BACKGROUND
- .2 GEOLOGY
  - .1 General
    - .1 Sandstone Intrusions
    - .2 Seam Splitting
    - .3 In-filled Rupture Features
    - .4 Intraswamp Dewatering Channels
    - .5 Floor Rolls
    - .6 Seat Earths
  - .2 Prince Colliery
    - .1 Hub Seam
    - .2 Roof Strata
    - .3 Floor Strata
  - .3 Lingan Colliery
    - .1 Harbour Seam
    - .2 Roof Strata
    - .3 Floor Strata
  - .4 Phalen Colliery
    - .1 Phalen Seam
    - .2 Roof Strata
    - .3 Floor Strata
- .3 EXISTING COLLIERIES
  - .1 General
  - .2 Prince Colliery
  - .3 Lingan Colliery
  - .4 Phalen Colliery

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 8.0 - SYDNEY COALFIELD MINING OPERATIONS

TABLE OF CONTENTS
(Continued)

FIGURES

8-1 Sydney Coalfield Seam Sequence
8-2 Sydney Coalfield
8-3 Prince Colliery - Hub Seam
8-4 Prince Colliery Face Layout
8-5 Lingan Colliery, 7W Face Layout
8-6 Phalen Colliery, One Line Diagram

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

8.0 SYDNEY COALFIELD MINING OPERATIONS

8.1 BACKGROUND

The Sydney Coalfield is located in Nova Scotia along the northeastern coastline of Cape Breton Island. It is part of a large Carboniferous basin of Pennsylvanian Age that dips under the sea between the shores of Cape Breton and Newfoundland.

Coal has been produced from the coalfield since 1720. In the nineteenth century, it supplied steam coal for ships plying the Trans-Atlantic routes and was profitable until around 1920. Between the two world wars, Government subsidies were necessary to support the industry and a general run down occurred until the mid 1960's.

The Cape Breton Development Corporation (CBDC) was formed in 1967 with a mandate to take over and phase out coal operations while establishing alternative employment. The oil crisis of 1973 reversed the corporate mandate and an expansion of the production from the coalfield ws initiated. All the collieries inherited on formation of CBDC have closed, the last being No. 26 Colliery in 1984 due to fire. The mines currently in operation have all been opened by CBDC; Lingan Colliery in 1973, Prince Colliery in 1976/77 and most recently, Phalen Colliery in 1987. Two access tunnels have been driven to the Harbour seam at the Donkin-Morien project, but development of the mine to production has been postponed until the market situation is more favorable.

While room-and-pillar mining has been used at shallower depths in the past, all workings are now based on longwall systems; advancing at Lingan, retreating at Prince and Phalen.

CBDC has progressively introduced state-of-the-art longwall methods and equipment into their collieries with resultant gains in productivity. However, there has been a rapid development of face automation and remote control equipment in the past two years and this report assesses to what extent CBDC collieries could benefit from its introduction. To carry out the assessment, it is necessary to understand the geologic setting and current equipment.

8.2 GEOLOGY

.1 General

Eleven major coal seams are present in the Sydney Coalfield, ranging in thickness from 1 m to 4.5 m, with six seams considered to be of economic importance. The coals are Middle to Late Pennsylvanian in age and ranked as high volatile A bituminous.

The coal seam sequence is shown in Figure 8-1. The seams are separated by relatively consistent intervals of rock strata composed of sandstone, siltstone, mudstone, minor shale and non-marine limestone. The entire sequence bears the characteristics of deposition in a fluvial environment upon a slowly subsiding coastal plain (Forgeron, 1986). The Sydney basin is essentially free of faulting away from the margins; however, folding has occured with flank gradients normally less than 10 degrees though varying from 2 degrees to 50 degrees. During Pleistocene glaciation, a veneer of glacial till was laid down on the erosional surface. Forgeron (1986) discussed the general geologic features which affect mining in the Sydney Basin, summarized as follows:

.1 Sandstone Intrusions

Occur when the normal roof strata (siltstone, mudstone and shale) are abruptly replaced by sandstone. The unpredictable features are believed to be in-filled paleo-river channels. The effects of the channels on mining are:

- Rock adjacent to sandstone pinch out zones tend to be weak.
- Sandstone-mudstone contact is a plane of weakness leading to rock falls.
- Channels may erode all or part of seam.
- The siliceous sandstone has high incendive sparking risk if struck by cutting picks of mining machines.
- Pyrite commonly associated with sandstone-coal contact increasing incendiveness.
- A roll generally occurs in the floor below point of maximum sandstone intrusion.
- Minor water can lead to poorer floor conditions.
- Coal production reduced, often by over 50%.

.2 Seam Splitting

Occurs in all the major seams, when stone bands divide the seam into one or more leaves and has the following effects on mining:

- Seam section altered, sometimes significantly.
- Unstable roof where rider seam is within 2 m of main seam.
- Weak floor strata where minor coal seams occur within 2 m of seam base.
- High quantities of gas may be introduced into workings from rider seams by contact through fractures created during mining.

.3 In-filled Rupture Features

Are irregular masses of stone that occur within the Harbour seam, in particular. Fortunately, most have been observed at shallow depth and planned mining areas should be unaffected. The stone has to be removed by a drilling and blasting technique. Cutting picks could create sparks. Roof conditions can deteriorate near the ruptures.

.4 Intraswamp Dewatering Channels

Are similar to the above features and have the same effects on mining. The difference lies in the coarseness of the sandstones/siltstones and the presence of bedding characteristics. Two examples were found near the end of Prince Colliery, 2 W face.

.5 Floor Rolls

Thought to be caused either by overlying sandstone or during tectonic movement, can rapidly change the normal 5 - 10 degree gradient to as high as 25 degrees. The width of the roll does not normally exceed 30 m. The floor rolls effects on mining include:

- Restricted movement of mining equipment.
- Accumulate water leading to soft floor.
- Shearer haulage chain can spring from roof to floor in area of rolls.
- Difficulties keeping conveyor pan on the working floor.

.6 Seat Earths

Forming the seam floors are highly variable in composition and may be hard or soft.

The hard floors can give incendive sparking when struck by shearer picks. The soft seat-earth hinders the movement of mining equipment and makes horizon control difficult. The roof support can be destabilized by floor penetration.

The locations of operating collieries within the Sydney Coalfield are shown in Figure 8-2 and a brief geologic description of each follows.

.2 Prince Colliery

Prince Colliery workings are in the Hub Seam. The colliery was opened from the highwall of a small open pit on Point Aconi. Intitial room-and-pillar extraction could not be sustained because:

- The bentonitic shale floor disintegrated under the mobile mining equipment.
- The feather edge of a massive sandstone lens in the roof strata caused severe roof support problems.

Consequently, the deeps were driven over 2000 m northward from the shoreline where the bedrock cover to the seabed exceeded 150 m; partial extraction was initiated by short, retreating longwall faces. The following description relates only to the longwall mining area.

.1 Hub Seam

The seam varies in strike from 128 degrees in the west, through 110 degrees near the deeps, to 128 degrees in the east; an overall dip of 3 degrees northward is maintained. The coal cleat strikes 81 degrees. A rider seam splits off the roof of the main seam to the north of the 0.2 m parting line shown on Figure 8-3. South of this line, in the east panels, the rider seam is included in the mining section; north of this line, only the main seam is extracted.

The main seam thickens in the northern part so that an extraction height of 2.0 to 2.4 m is maintained generally. A major sandstone channel has eroded the Hub Seam leaving a seam as thin as 0.5 m in places causing production and mine layout problems. The extent of the channeling has not yet been fully determined.

.2 Roof Strata

The strata overlying the Hub Seam is an interbedded succession of sandstone, siltstone and mudstones, ranging in thickness over the current mining area from 150 m to 215 m to the seabed. The immediate roof above the Hub Rider seam - southern area - comprises a mudstone about 1 m thick overlain by competent siltstone. In the northern area, at some distance from the sandstone channel, a 2.5 m shaly mudstone unit forms the immediate roof, overlain by an interbedded succession of sandstones and mudstones. As the erosion channel is approached, the immediate roof is sandstone. This is usually the case in all west developments and the deeps. The sandstone is medium grained, crossbeded with carbonaceous material along bedding partings.

Tests on sandstone core from Hole PM 28 located at the west end of 2W Panel give the following results:

	Range	No. Obs.	Average Strength MPa	Standard Deviation MPa
Unconfined Comp. Strength	20.3-45.7 MPa	11	30.5	7.5
Tensile Strength	1.2- 2.9 MPa	7	1.8	0.6
Young's Modulus	6700-8100 MPa	2		
Poisson's Ratios	0.42	2		

It is anticipated that the sandstone would have a high Ignition Temperature Potential (ITP) and the mudstone a neglible ITP.

A study of jointing in the roof strata along the shore line indicates the presence of two equally prominent sets striking at 20 degrees and 105 degrees.

.3 Floor Strata

A detailed study of the immediate floor, carried out by CBDC showed that the bentonitic shale encountered in the old room and pillar section thinned to less than 2 cm in the deeps at 1 W Panel. The immediate floor in the current and future mining area generally comprises a competent siltstone in the western areas and a sandstone over 2 m thick in the northeast area. Tests on the siltstone floor showed 32% and 39% quartz greater than 5 m, indicating an intermediate ITP.

.3 Lingan Colliery

Lingan Colliery workings are in the Harbour Seam. The colliery is developed by arched deeps in the seam to a distance of some 4.5 km from shore. Initially, under shallow cover to the seabed, coal was produced by room-and-pillar mining. After a solid bedrock cover of 250 m had been reached, the mining method changed to advancing longwalls.

.1 Harbour Seam

The strike of the seam is constant at 100 degrees ± 4 degrees dipping northward at 6.5 degrees to 8 degrees. The cleat strikes 70 degrees. Recent operating faces show a seam thickness variation of 1.50 m to 2.00 m. Drillhole H1A located 2.5 km downdip shows a seam thickness of 1.9 m. This confirms the established Harbour seam continuity throughout the coal basin. Slight thickness variation due to the sand filled scour channels exists throughout the mine.

.2 Roof Strata

The Harbour seam near the current operating panels is overlain by about 490 m of interbedded sandstone, shales and siltstone to the seabed. The immediate roof is a competent mudstone with some siltstone partings. A number of scour channels lie at or near the roof of the seam. Channels in the down dip extension of the Lingan Block are unpredictable, not only in their location, but especially in the depth of scouring associated with the channels.

The ITP of one channel was detailed along the 3W Panel maingate: The mudstones had a quartz content from 1.5% to 39% (neglible to intermediate ITP) whereas the sandstones had a range from 52% to 79% (high ITP). In this particular case, the scour channels never got closer than 1 m above the seam.

A shoreline survey of joint orientations show a single dominant set striking 90 degrees.

.3 Floor Strata

Generally, the Harbour Seam floor is a hard mudstone which forms a good mining floor. However, in the central and western parts of recent mining areas, the immediate floor was a soft shale up to 0.5 m thick. Since the face equipment was not designed to operate on soft floors, this shale gave a high ash dilution.

The unconfined compressive strength of the soft floor was estimated using the "NCB Cone Indenter", giving a range of 14 MPa to 44 MPa. The soft floor has a low ITP.

In the area of latest longwall faces (7 W and 10E) the floor shale has thinned down to less than 10 cm and hardened considerably. In some areas, there is now a sandstone floor which has a high ITP and sparking occurs if cutter picks strike it.

.4 Phalen Colliery

The Phalen Colliery extracts the Phalen seam which lies about 150 m below the Harbour seam workings in the Lingan Colliery area. The Phalen seam outcrops south of the Lingan Minesite.

.1 Phalen Seam

The strike of the seam is fairly constant at 100 degrees dipping 12 degrees N down to -600 m; below this level, the strike varies between 90 degrees and 110 degrees with a generally shallower dip of 6 degrees N. The New Waterford Anticline and Syncline axes trend across the resource block, but the structural relief on these folds appears to be minimal.

The Phalen seam is 2.1 m to 2.3 m thick in the southeastern part of the resource block. A shale parting develops 0.9 m below the roof of the seam along a northeasterly line (Figure 3-4) and thickens towards the northwest, splitting off a rider seam. The main seam thins both to the west and north.

.2 Roof Strata

The Phalen seam lies 150 m to 130 m below the Harbour seam; the interval thins slightly in a northerly direction. Generally, a mudstone forms the immediate roof; on-shore drilling indicates that this mudstone is relatively weak, but drillholes from the Lingan Colliery and exploration hole H1A indicate a more competent nature.

Sand filled scour channels have been encountered in the roof of the main seam, west of the zone where the rider seam splits off. The first longwall face on the west side of the colliery has had weak roof conditions. Three thin coal bands 3 cm to 8 cm thick are present in the immediate roof. Smooth listric surfaces beneath each coal band form planes of weakness. The 1 m thick weak roof may fall with the coal at times, though recently, it is controlled to within 0.15 m of the top of the coal seam.

Sandstone can appear in the roof in channel areas leading to risk of incendive sparking if cutter picks strike it. Roof conditions are generally good in the east side of the mine.

.3 Floor Strata

Mudstone forms the immediate floor in all intersections and is generally competent. However, over part of the west face, a rider seam occurs less than 20 cm below the seam base and when this occurs, the floor breaks up. The problem is anticipated to affect approximately 25% of IW panel then diminish on subsequent panels.

8.3 EXISTING COLLIERIES

.1 General

The present mine layouts of the CBDC Collieries are based on a central system of dip developments from which longwall panels are worked with the roadways along the strike. The panels vary from at or near right angles to the main deeps in Lingan to near 60 degrees to main deeps in parts of Phalen and Prince. Panels have long runs frequently in excess of 1000 m, in some cases up to 3000 m, and their width vary from 100 m to 200 m to meet seabed strain limitations.

Typically, pillars are left between panels. The width of panels is selected on subsidence criteria and to provide roadway stability. Pillar widths increase as the panels get deeper. With the retreat mining system, it is advantageous to eliminate the pillars and future mine plans at Phalen and Lingan show this alternative for deeper panels.

In the past, the bulk of production from the Sydney Coalfield has been from advance workings. However, both Prince and Phalen Collieries use retreat mining systems. Lingan uses an advancing system and has recently introduced an advanced heading system on 7W panel. Present plans aim to convert the colliery to retreat mining as soon as it becomes practical.

The intake and return roadways and face lines for advancing panels are developed by DOSCO roadheaders taking the coal seam and a roof brushing. Support is by RSJ arches for the gateroads. For retreat workings at Prince, panel developments are driven by DOSCO dirtheaders with a square cross-section taking the seam and occasionally, a small floor brushing. Support is by RSJ girders attached by clevis attachments to similar section RSJ legs. At Phalen Colliery, a VME shortwall miner is also used for gateroad development.

Generally, the whole seam is extracted from floor to roof. Floor rock is mined where exceptionally soft conditions occur or where the floor breaks up due to the proximity of a underlying rider seam. Where adverse roof conditions are encountered, it is common to leave a thin layer of roof coal to assist strata control. At Prince Colliery, roof coal is left on the east side faces to improve run-of-mine quality. Selective mining by leaving both roof and floor coal may be desirable from a quality point of view at the proposed Donkin-Morien Colliery.

Extraction height varies from as low as 1.5 m at Lingan to over 2.4 m on Phalen east face. The faces are aligned between approximately 49 degrees and 66 degrees in the main cleat direction.

All mines employ exhausting main ventilation. Methane drainage is used on all faces at Lingan and will become necessary at Phalen as both these mines are considered gassy. Gas makes at Prince Colliery are lower and drainage is not currently necessary.

Any discussion of potential remote control and automation in the Sydney Coalfield must take into account present practices. CBDC has traditionally been a leader in longwall face technology and advance systems have been installed in all their collieries. A description of 'typical' existing face equipment is provide in subsequent paragraphs to provide the starting point for discussion on further automation and remote control.

.2 Prince Colliery

Prince Colliery was originally worked by room-and-pillar methods, but this system was abandoned after three years because of floor and roof control problems allied to poor coal quality. Slopes were driven down dip under the sea until sufficient cover was gained to allow longwall workings using single entry gate roads ("single entry U layout").

Longwall faces, which are worked on retreat, are around 100 m long and pillars 55 - 60 m wide are left between panels.

The workings are at a distance of about 4 - 5 km from the surface. The Colliery is served by three operating slopes from surface to shoreline and by five downdip of shoreline. The two air return slopes are connected to a ventilation shaft.

The Hub Seam is less gassy than the Harbour or Phalen seams and methane drainage has not been found necessary.

A diagramatic layout of the face is shown in Figure 8-4.

The face is supported by Hemscheidt 2 leg, 320 ton shield supports and Hemscheidt 4 legged face end supports. The power loader is a 300 HP Anderson Strathclyde, Type FIDD, double drum shearer, with Dynatrack Chainless haulage, loading onto a Halbach and Braun armoured face conveyor with twin in-board 22 mm chains. The A.F.C. delivers onto an 0.76 m Huwood P100 stageloader fitted with a 75 HP motor.

Development entries are driven by Dosco dintheaders with a square cross-section taking the seam and occasionally a small floor brushing. The support is by RSJ girders and props.

The Transmitton Ltd. remote monitoring system at Prince Colliery, installed in 1986, constantly monitors the faces, the main fan and the surface plant. The face monitoring includes methane, air velocity and CO. A more detailed description of the monitoring system is given in Appendix F.

.3 Lingan Colliery

Lingan Colliery is served by four slopes from the surface with a fifth slope driven from underground. Direct rope haulage systems are used for transport of men and material and a conveyor system used for transport of coal.

The workings are laid out on a panel and pillar system using advancing longwall techniques with full caving. Two to three longwalls are operated at any time. Past faces were based on U-layout, but the most recent 7W face has an advanced heading.

Plans call for elimination of pillars and eventual conversion to retreat mining layouts. Workings are presently about 600 m below sea level. District methane emission rates are around 20 m^3/t, with methane drained by cross-measure boreholes in the tail gate.

7 West is an advancing longwall face, 230 m long with a conventional rip behind the face in the tail gate and an advanced head 30 m in front at the main gate end. The general layout of the face is shown in Figure 8-5.

The face is supported by Hemscheidt 2 leg, 320 ton shield supports on the face and Dowty 4 legged 500 ton pack hole supports with a 6 leg 750 ton buttress waste edge support at the coal gate end. The coal getting machine is a 300 HP Anderson Strathclyde Type 270 AMBROAS double drum shearer with Eicotrac chainless haulage which loads onto a Halbach & Braun armoured face conveyor with double inboard 26 mm chains. The A.F.C. has a 250 hp drive with in-line gearbox at the tail gate and 250 hp right angled gearbox at the coal gate. The drive is brought in the gate road at the coal gate end and loads onto a 0.76 m stageloader which is positioned in the right hand side of the gate looking inbye and 1.22 m off the centre line.

The tail gate rip is drilled and fired and loaded onto a mini armoured conveyor which loads onto the back end of the A.F.C. A Webster combined drill loader is used at this rip.

The coal gate advanced head is driven by a Dosco MKIIB boom loader, ventilated by a Peacock MRDE exhaust fan and scrubber.

The tail gate pack is a 1.5 m square hardwood chock and an open 0.76 m breaker chock built at the face immediately behind the A.F.C.

The coal gate pack is a 1.5 m square solid chock built behind the first two pack hole chocks with a 0.76 m solid chock built immediately behind the A.F.C. in-line with the edge of the roadway behind the replaced arch leg at the coal gate face entrance. Initially, there is a 0.9 m gap left between the 0.7 m roadside chock and the 1.5 m solid chock to accommodate a monolithic pumped pack which is used to prevent leakage of air through the initial face line.

At the coal gate junction with the face, a 200 ton Dowty 4 leg, in-line T support, is used to support the arches while the face side leg is removed to move the coal gate A.F.C. drive over when the shearer has cut out.

This support is used only to support the arch while the arch leg is out and not to push over the face unit. The A.F.C. drive is connected to a "T" rail bolted to the stageloader which allows the A.F.C. drive to slide along the stageloader and maintain its relative loading position onto the stageloader.

There is a remote monitoring system at Lingan Mine, but the faces are not yet equipped with the latest control equipment such as electro-hydraulic valves.

The remote monitoring system, supplied by Conspec Controls Ltd., monitors the three operating faces, three pumping stations, the main fan and the surface methane extraction plant. The face outstations include facilities for monitoring methane concentrations and flows and air velocities. A fuller description of the system is given in Appendix G.

.4 Phalen Colliery

Phalen Colliery went into production in 1987 with two longwall retreat faces. Plans call for a third similar face as the colliery develops. Three slopes are driven from surface to below the shoreline. A further two slopes are driven, making five in all, connected to a ventilation shaft at the shoreline.

The coal is mined using a longwall retreat system with in-seam single-entry gateroad drivages and a back bleeder system for ventilation.

The Phalen seam is gassy and gas emission rates could be higher than those experienced at Lingan due to the destressing effect of overlying workings and thin rider seams in adjacent strata. Methane drainage will be required.

The present faces are approximately 141 m long with 80 m pillars. With increasing cover downdip, it will be possible to lengthen the faces and eliminate the pillars.

An electrical face layout is shown in Figure 8-6. The face is supported by Dowty 2 leg, 550 ton shield supports fitted with a micro-processor based electro-hydraulic control system. Face end supports are Dowty 4 leg, 450 ton chock shields. The power loader is a Anderson Strathclyde AM500 double ended ranging drum shearer with Eicotrack chainless haulage and loading onto a side discharge Dowty A.F.C. with twin in-board chains. The A.F.C. delivers onto a Dowty Meco heavy duty 222 mm x 1064 mm stageloader.

Gateroads are driven by a Dosco MKIIB roadheader and by Westfalia Lunen VM-E shortwall miner. The bottom level is supported by 5 m Hollybank trapezoidal arches while the top level uses 5.5 m three piece arches.

The roof supports have a micro-processor based electro-hydraulic control system. The Dowty type B-2 button (MS14) system provides the following features:

- Bi-directional automatic remote control programmed from the face end computer.
- Bi-directional adjacent control, hard wired in the chock control unit.
- In chock hydraulic control.

The facility is provided for the operation of the supports from the gate end for support set only and for the addition of shearer initiated support control at a later date.

Information gathered by the gate end computer can be transmitted to surface with the telemetry system for management information and remote control.

The 4-leg gate end supports utilize a uni-directional adjacent control Dowval system.

The face conveyor and stageloader are controlled by a Davis of Derby Mk2 Sivad control and communcations system.

The AM500 DERDS is fitted with remote control and monitoring facilities. While fitted out to accept radio control, the shearer has initially been operated using umbilical cord remote control. General monitoring includes:

- All main power supplies for electronic units, control relays, etc., by LED's.
- Main 3 ph supply by voltmeter and ammeter.
- Control relays for coil voltage by LED's.
- Machine speed indication.

- Electronic check of pilot circuit for open circuits and direct short circuits to earth.
- Temperature monitoring of motor bearings, motor winding and water.

The colliery has a remote monitoring system provided by Transmitton.

FIGURE 8-1

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SYDNEY COALFIELD SEAM SEQUENCE

SYDNEY COALFIELD SEAM SEQUENCE

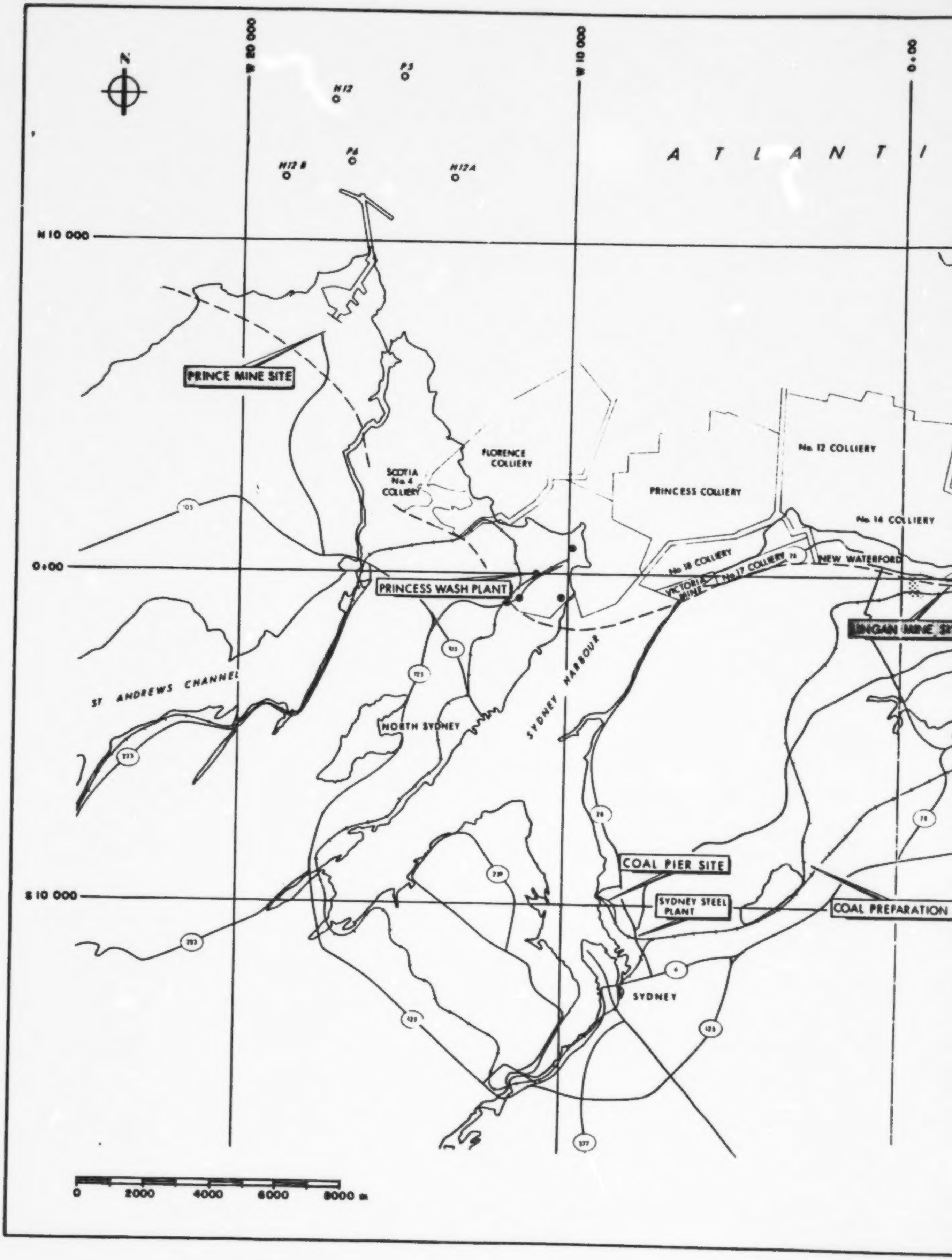
Seam	Coal Interval Thickness (m)	Interseam Thickness (m)
Point Aconi	1.0 - 2.0	
		70 - 90
Lloyd Cove	1.0 - 3.0	
		60 - 80
Hub Zone*(1)	3.0 -13.0	
		90 - 110
Harbour (2)	2.0 - 4.5	
		60 - 80
Bouthillier	0.5 - 1.0	
		20 - 40
Back Pit	0.5 - 1.0	
		30 - 35
Phalen (3)	0.5 - 2.0	
		40 - 60
Emery	0.5 - 1.5	
		130
Gardiner	0.5 - 1.5	
		330
Mullins	1.0 - 2.0	
		175
Tracey	1.0 - 2.0	

(After Haites, 1951; Forgeron, 1980; including Donkin-Morien data).
* May include up to 10 m of major rock partings

(1) Prince Mine

(2) Lingan

(3) Lingan-Phalen


N
W 20 000
W 10 000
0+00
H12
P3
H12 B
P6
H12A
A T L A N T I
N 10 000
PRINCE MINE SITE
FLORENCE COLLIERY
SCOTIA No. 4 COLLIERY
No. 12 COLLIERY
PRINCESS COLLIERY
No. 14 COLLIERY
No. 18 COLLIERY
VICTORIA MINE
No. 17 COLLIERY
NEW WATERFORD
0+00
PRINCESS WASH PLANT
LINGAN MINE S
ST ANDREWS CHANNEL
NORTH SYDNEY
SYDNEY HARBOUR
COAL PIER SITE
S 10 000
SYDNEY STEEL PLANT
COAL PREPARATION
SYDNEY
0
2000
4000
6000
8000 m

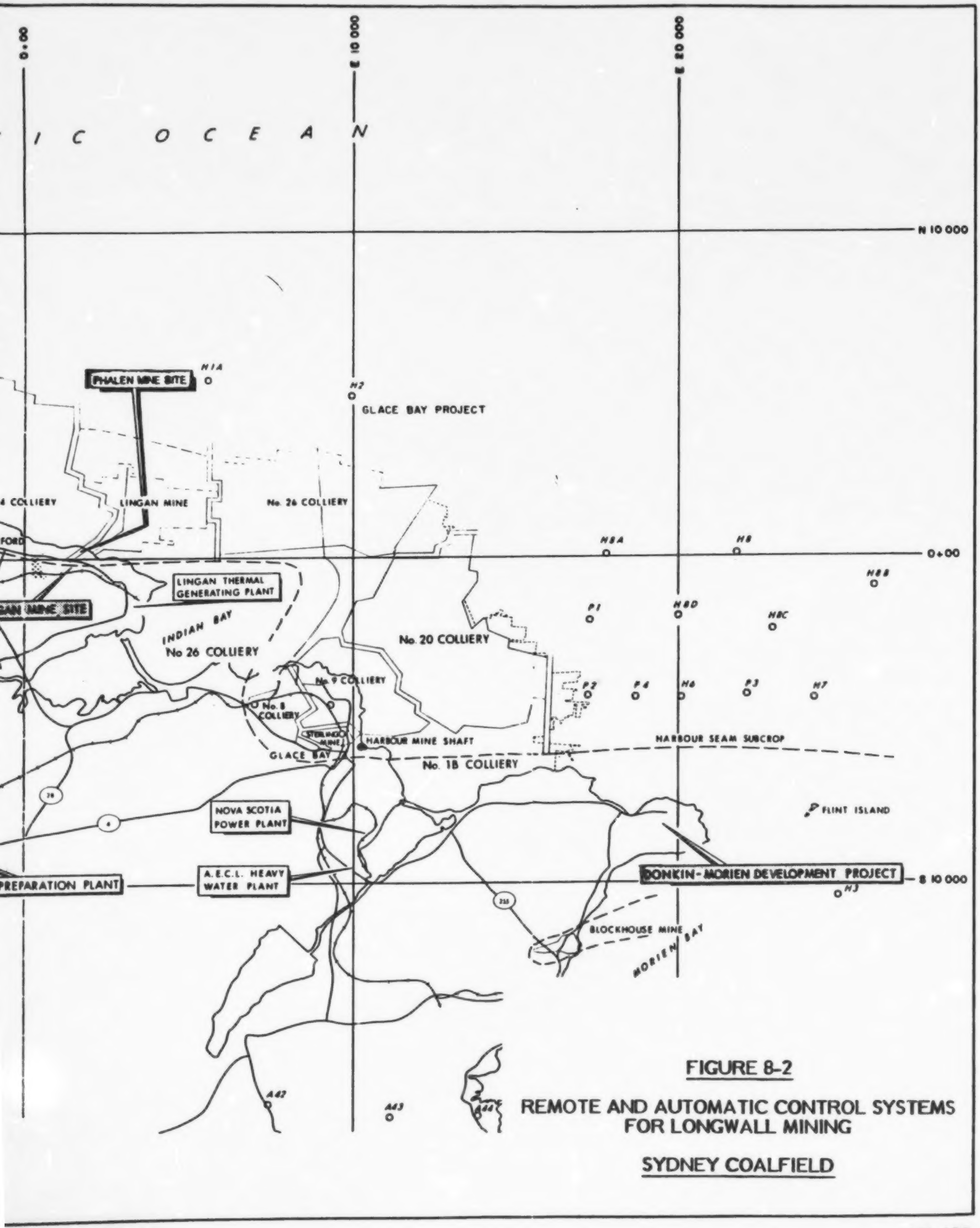

0+00
E 10 000
E 20 000
I C O C E A N
N 10 000
PHALEN MINE SITE
H1A
H2
GLACE BAY PROJECT
COLLIERY
LINGAN MINE
No. 26 COLLIERY
H8A
H8
0+00
H8B
LINGAN THERMAL GENERATING PLANT
GAN MINE SITE
INDIAN BAY
No 26 COLLIERY
P1
H8D
H8C
No. 20 COLLIERY
No. 9 COLLIERY
P2
P4
H6
P3
H7
No. 8 COLLIERY
STERLING MINE
HARBOUR MINE SHAFT
HARBOUR SEAM SUBCROP
GLACE BAY
No. 1B COLLIERY
FLINT ISLAND
NOVA SCOTIA POWER PLANT
PREPARATION PLANT
A.E.C.L. HEAVY WATER PLANT
DONKIN-MORIEN DEVELOPMENT PROJECT
S 10 000
H3
BLOCKHOUSE MINE
MORIEN BAY
A42
A43
A44

FIGURE 8-2

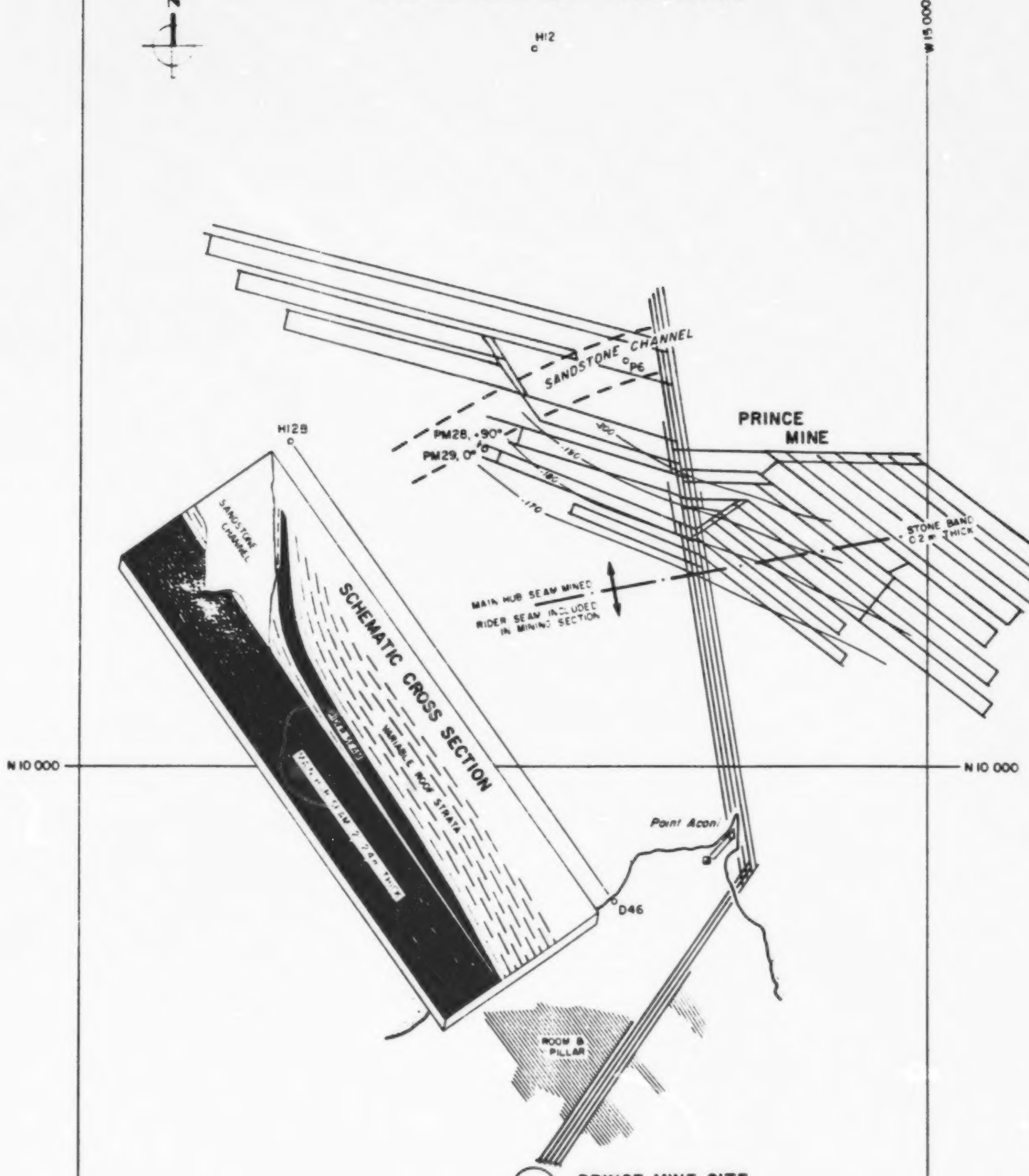
REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

SYDNEY COALFIELD

FIGURE 8-3

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PRINCE COLLIERY - HUB SEAM



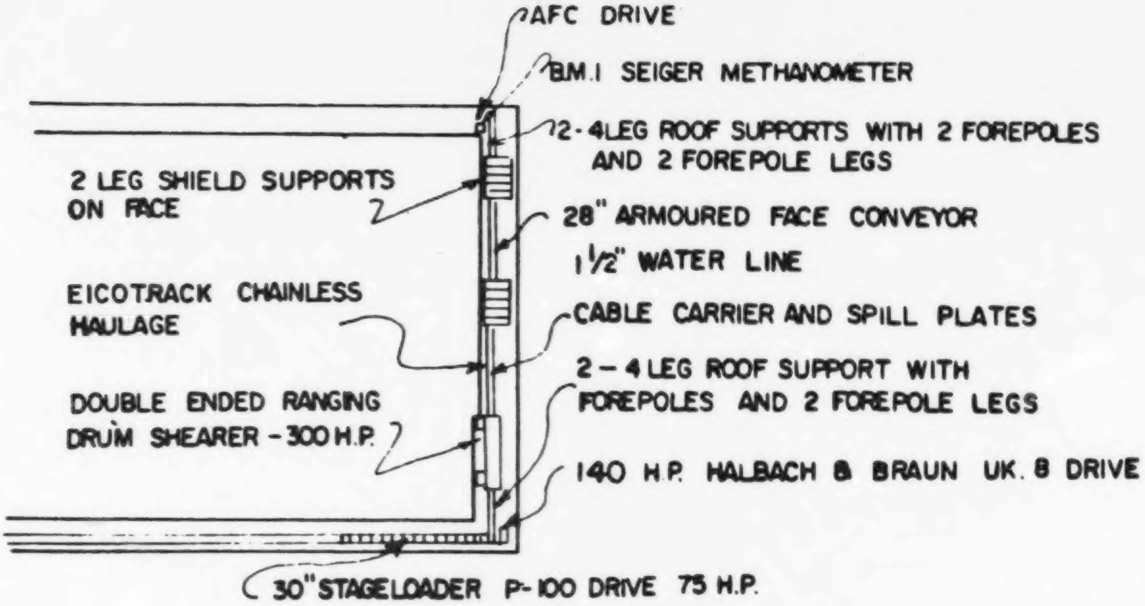
N
W15 000
H12
SANDSTONE CHANNEL
P6
PRINCE MINE
H129
PM28, -90°
PM29, 0°
-200
-190
-180
-170
STONE BAND 0.2 m THICK
MAIN HUB SEAM MINED
RIDER SEAM INCLUDED IN MINING SECTION
SANDSTONE CHANNEL
SCHEMATIC CROSS SECTION
VARIABLE ROOF STRATA
N10 000
N10 000
Point Aconi
D46
ROOM & PILLAR
PRINCE MINE SITE

AR-122

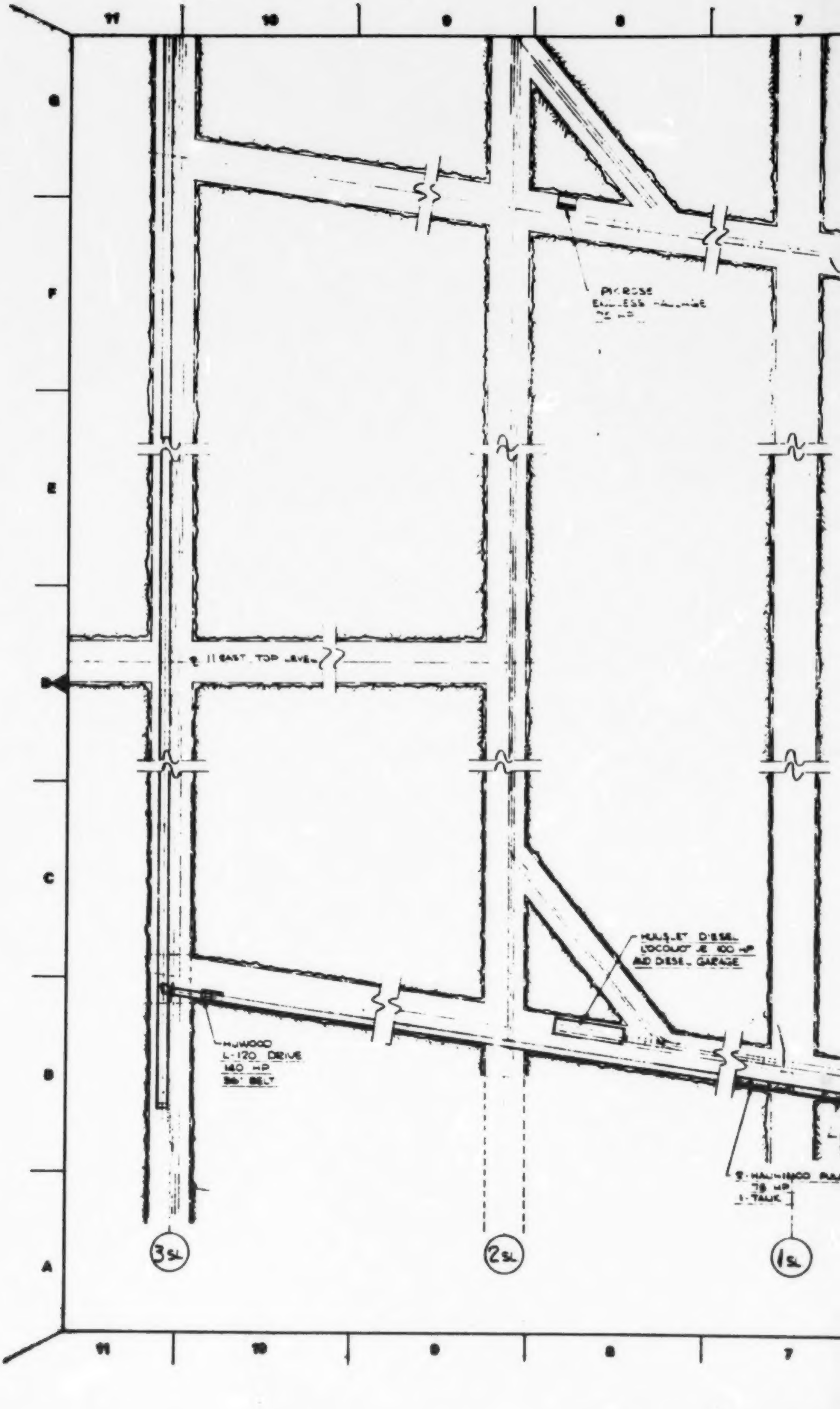
FIGURE 8-4

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING

PRINCE COLLIERY FACE LAYOUT


AFC DRIVE
B.M.I SEIGER METHANOMETER
2-4 LEG ROOF SUPPORTS WITH 2 FOREPOLES AND 2 FOREPOLE LEGS
2 LEG SHIELD SUPPORTS ON FACE
28" ARMOURED FACE CONVEYOR
1 1/2" WATER LINE
EICOTRACK CHAINLESS HAULAGE
CABLE CARRIER AND SPILL PLATES
2 – 4 LEG ROOF SUPPORT WITH FOREPOLES AND 2 FOREPOLE LEGS
DOUBLE ENDED RANGING DRUM SHEARER - 300 H.P.
140 H.P. HALBACH & BRAUN UK. 8 DRIVE
30" STAGELOADER P-100 DRIVE 75 H.P.

Source:


11
10
9
8
7
G
F
E
D
C
B
A
PICKROSE
ENDLESS HAULAGE
75 HP
℄ 11 EAST TOP LEVEL
HUNSLET DIESEL
LOCOMOTIVE 100 HP
AND DIESEL GARAGE
HUWOOD
L-120 DRIVE
140 HP
36" BELT
2-HUWOOD
75 HP
1-TANK
3SL
2SL
1SL

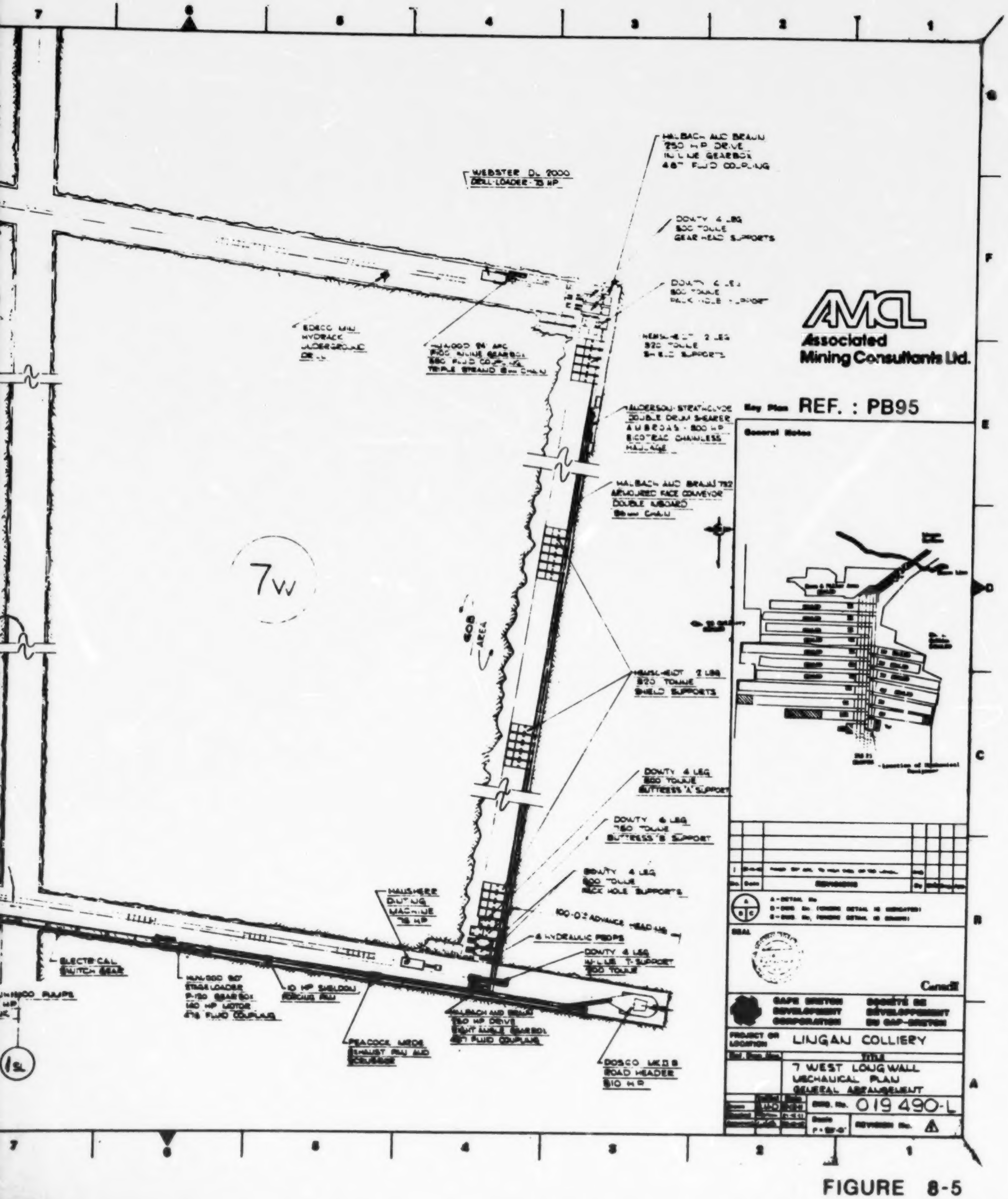
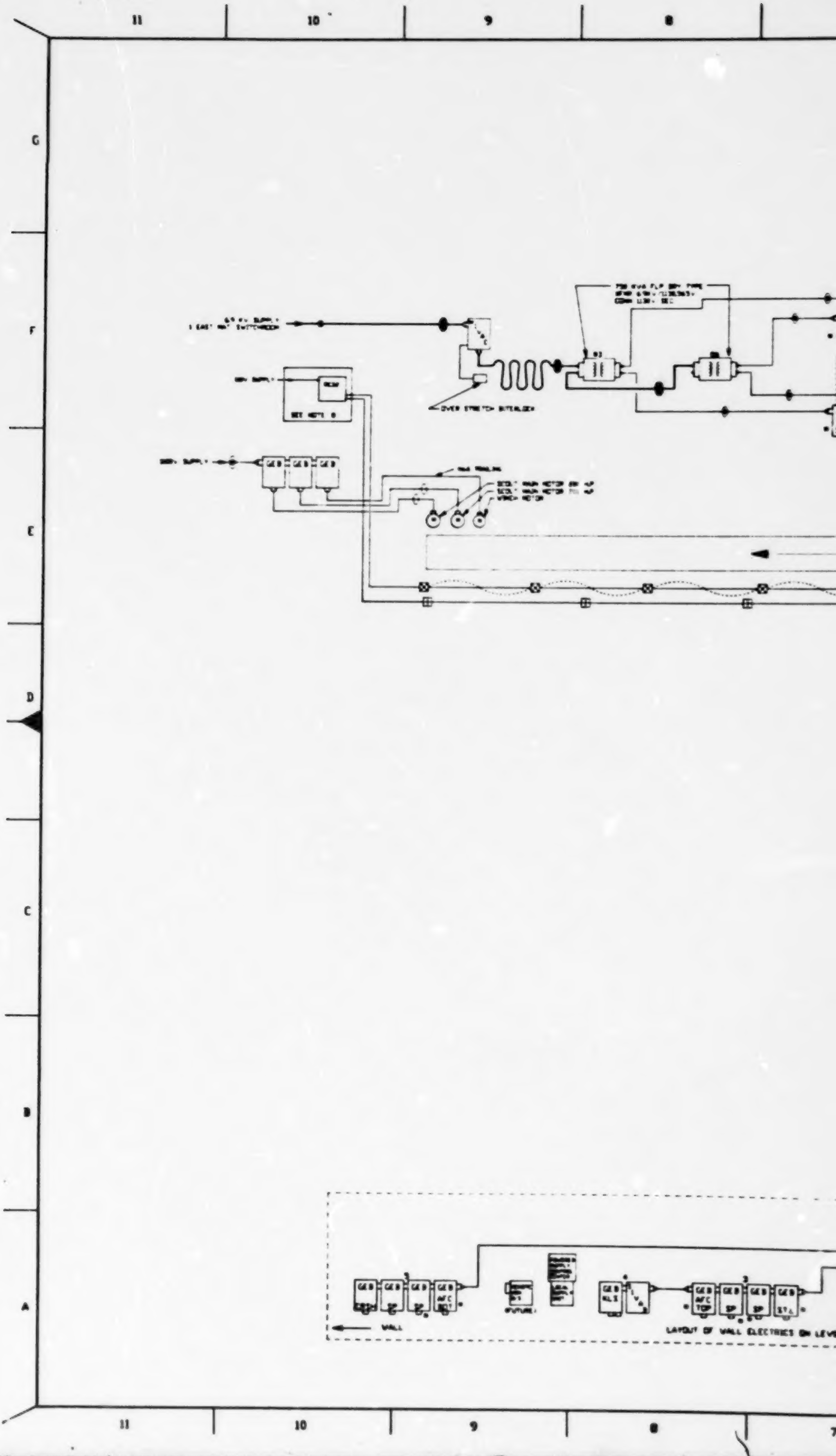
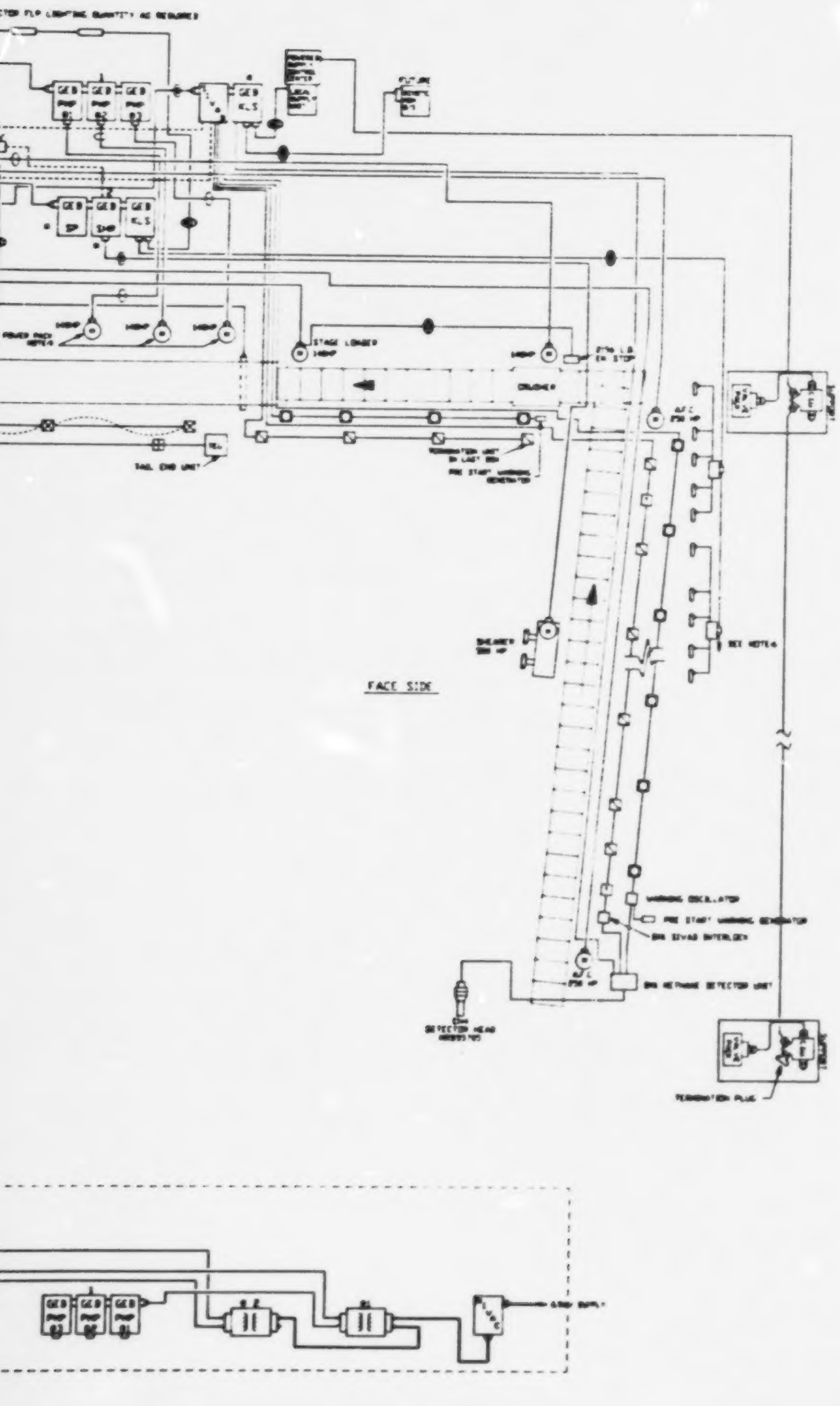

HALBACH AND BRAUN
250 HP DRIVE
IN LINE GEARBOX
48" FLUID COUPLING
WEBSTER DL 2000
DRILL-LOADER - 75 HP
DOWTY 4 LEG
800 TONNE
GEAR HEAD SUPPORTS
DOWTY 4 LEG
800 TONNE
PACK HOLE SUPPORT
EDECO MINI
HYDRACK
UNDERGROUND
DRILL
HUNWOOD 24" ARC
F500 INLINE GEARBOX
550 FLUID COUPLING
TRIPLE STRAND 18mm CHAIN
HEMSCHEIDT 2 LEG
320 TONNE
SHIELD SUPPORTS
ANDERSON STRATHCLYDE
DOUBLE DRUM SHEARER
A M 500 AS - 500 HP
BICOTRAC CHAINLESS
HAULAGE
HALBACH AND BRAUN 782
ARMOURED FACE CONVEYOR
DOUBLE INBOARD
18mm CHAIN
7W
GOB AREA
HEMSCHEIDT 2 LEG
320 TONNE
SHIELD SUPPORTS
DOWTY 4 LEG
800 TONNE
BUTTRESS 'A' SUPPORT
DOWTY 4 LEG
750 TONNE
BUTTRESS 'B' SUPPORT
DOWTY 4 LEG
800 TONNE
PACK HOLE SUPPORTS
HAUSHERR
DINTING
MACHINE
75 HP
100-0" ADVANCE HEADING
6 HYDRAULIC PROPS
DOWTY 4 LEG
IN LINE T-SUPPORT
700 TONNE
ELECTRICAL
SWITCH GEAR
HUNWOOD PUMPS
HUNWOOD 507
STAGE LOADER
F-120 GEARBOX
140 HP MOTOR
475 FLUID COUPLING
10 HP SHELDON
FORCING FAN
HALBACH AND BRAUN
750 HP DRIVE
RIGHT ANGLE GEARBOX
487 FLUID COUPLING
PEACOCK MK06
EXHAUST FAN AND
SCRUBBER
DOSCO MK II B
ROAD HEADER
510 HP
1SL
AMCL
Associated
Mining Consultants Ltd.
Key Plan
REF. : PB95
General Notes
Canada
CAPE BRETON
DEVELOPMENT
CORPORATION
SOCIÉTÉ DE
DÉVELOPPEMENT
DU CAP-BRETON
PROJECT OR LOCATION
LINGAN COLLIERY
TITLE
7 WEST LONGWALL
MECHANICAL PLAN
GENERAL ARRANGEMENT
DWG. No. 019 490-L
Scale
1" = 50'-0"
REVISION No. 1
1
2
3
4
5
6
7
A
B
C
D
E
F
G

FIGURE 8-5


11
10
9
8
G
F
E
D
C
B
A
OVER STRETCH INTERLOCK
SEE NOTE 8
GEB
GEB
GEB
WINCH MOTOR
GEB
SP
GEB
SP
GEB
AFC
(FUTURE)
GEB
GEB
AFC
TOP
GEB
SP
GEB
SP
GEB
ST
WALL
LAYOUT OF WALL ELECTRICS ON LEVE
11
10
9
8

6 5 4 3 2 1


FLP LIGHTING QUANTITY AS REQUIRED
GEB PMP 03
GEB PMP 02
GEB PMP 01
GEB KLS
GEB SP
GEB SHP
GEB KLS
POWER PACK
STAGE LOADER
CRUSHER
TAIL END UNIT
TERMINATION UNIT
PRE START WARNING GENERATOR
A.F.C.
SHEARER
SEE NOTE 6
FACE SIDE
WARNING OSCILLATOR
PRE START WARNING GENERATOR
BMI SIVAD INTERLOCK
BMI METHANE DETECTOR UNIT
DETECTION HEAD
TERMINATION PLUG
GRID SUPPLY

CABLE LEGEND

No 3/0 TRAILING CABLE
3/0 TRAILING CABLE
No 18/3 COND CONTROL CABLE TYPE 63
No 18/2 COND CONTROL CABLE TYPE 62
4/0 PVA CABLE
8 KV EPR SWA MINE POWER CABLE 3/0
8 KV SHD GC TRAILING CABLE 1/0

CHAIN TENSIONER INTERLOCK
FACE LOCKOUT BOX
FACE SPEAKER BOX
AMPLIFIER
PRE-START WARNING GENERATOR
PULLKEY
SELECTOR SWITCH
LIGHTING TRANSFORMER 5 KVA 1130/110V WITH S.E.L.
GATE END BOX 550/1130 200 AMP

KEY PLAN

GENERAL NOTES

1 ALL ELECTRICAL EQUIPMENT IS CERTIFIED FLP AND/OR IS
2 THE PULLCORD EXTENDS ALONG THE FULL LENGTH OF THE BELT CONVEYOR SYSTEM
3 BMI SIVAD INTERLOCK & WARNING OSCILLATOR TO BE INSTALLED PER DWG No1296 REV I
4 GEB MARKED (*) ARE EQUIPPED WITH REMOTE MONITORING
5 THE GEBS ARE ARRANGED 1 TO 5 WITH BANK 5 BEING CLOSEST TO THE FACE
6 FACE LIGHTS ARE LOCATED ON EVERY SECOND ROOF SUPPORT
7 FOR SEQUENCING STAGE LOADER & A.F.C. SEE DWG No1487
8 REFER TO DWG No1534 FOR CONVEYOR CONTROL WIRING DETAILS
9 REFER TO DOWTY DWG FOR DETAILS ON ELECTRO HYDRAULIC ROOF SUPPORT CONTROLS. THIS INCLUDES CONTROLS FOR THE HYDRAULIC POWER PACKS & PUMPS

No	Date	REVISIONS	By	Ch'd		

A-DETAIL NO
B-DWG NO (WHERE DETAIL IS INDICATED)
C-DWG NO (WHERE DETAIL IS DRAWN)

SEAL

FIGURE 8-6

Canada

CAPE BRETON
DEVELOPMENT
CORPORATION

SOCIÉTÉ DE
DÉVELOPPEMENT
DU CAP-BRETON

PROJECT OR LOCATION: PHALEN COLLIERY

TITLE: ONE LINE ELECTRICAL LAYOUT OF A TYPICAL RETREAT WALLFACE

DWG No LP-068

AR-122

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 9.0 - SYDNEY COALFIELD FURTHER AUTOMATION

TABLE OF CONTENTS

9.0 SYDNEY COALFIELD FURTHER AUTOMATION

- .1 INTRODUCTION
- .2 GEOLOGIC CONSTRAINTS
  - .1 Sandstone Intrusions
  - .2 Weak Roof
  - .3 Seam Thickness
  - .4 Coal Quality
  - .5 Soft Floor
  - .6 Hard Floor
  - .7 Gradients and Rolls
- .3 ROOF SUPPORT SYSTEMS
  - .1 Phalen Colliery
  - .2 Lingan and Prince Collieries
  - .3 Cost
- .4 SHEARER CONTROL SYSTEMS
  - .1 Cost
- .5 OTHER SYSTEMS
  - .1 Pick Force Guidance System
  - .2 MACE
  - .3 Expert System
  - .4 SUMMIT
- .6 TRAINING CONSIDERATIONS
  - .1 Preparation of Training Material
  - .2 System Training
  - .3 Operational Assistance
- .7 BENEFITS
  - .1 Manpower
  - .2 Production

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
SYDNEY COALFIELD FURTHER AUTOMATION

9.0 SYDNEY COALFIELD FURTHER AUTOMATION

9.1 INTRODUCTION

In assessing the future automation and remote control of longwall faces within the Sydney Coalfield, it is necessary to consider the geologic environment, safety, reliability, cost effectiveness and training requirements.

It is recognized that the CBDC mines use advanced technology and this is particularly so at the new Phalen Colliery. Experience has demonstrated that automation/remote control should be introduced in a staged manner. A mining system has to operate reliably under manual control before the system is remotely or automatically controlled. The face equipment must be proven for its cutting and support duty in the local conditions and face personnel must be familiar with the function and maintenance of the equipment. Individual systems and sub-systems must be automated before they are interlinked. Only in this way will the management and workforce gain sufficient confidence in the systems to ensure proper operational procedures and gain the potential benefits of automation.

The present coal face equipment at the CBDC mines lends itself to automation. Potential gains can be achieved at Lingan and Prince Collieries where powered supports are not fitted with electro hydraulic valves.

9.2 GEOLOGIC CONSTRAINTS

The geologic condtions of the Sydney Coalfied impose a number of constraints on the application of control systems.

.1 Sandstone Intrusions

The presence of sandstone intrusions in the roof must be recognized since they can cause incendive sparking if struck by cutter picks. Thus, any horizon control system must be able to anticipate the location of the sandstone channels. Often the gamma-ray emissions from sandstone are lower than for shale roof strata so a gamma-ray sensor could indicate sandstone as coal and the risk of cutting into the sandstone increases. The pick force sensor system would locate the sandstone roof instrusion only when it cut into it. Where sandstone intrusions are likely or known to occur, then the 'recognition' traverse mode would appear to be the safest.

.2 Weak Roof

There are areas of the coalfield where weak roof conditions occur, particularly where rider seams splits off, as at Phalen Colliery. There is benefit leaving coal in the roof thick enough to act as a beam. The MIDAS type horizon control system is ideal for this situation provided tests demonstrate a significantly higher natural gamma-ray emission from the roof strata than from the coal.

.3 Seam Thickness

Seam thickness in CBDC mines varies from 1.5 m to 3 m. Where the lower end of the range occurs at Lingan and anticipated for the northwesterly faces of Phalen, then leaving 0.15 m - 0.25 m of roof coal severely limits the extraction height possible within the seam and could lead to reduced production rather than increased. It also wastes valuable reserves.

.4 Coal Quality

Sydney Coalfield seams are notoriously variable in quality both in arial extent and within a particular seam section. Generally, the inferior coal containing high sulphur occurs at the top and bottom of the seam. The use of automatic horizon control systems based on gamma-ray sensor could be appropriate where roof or floor coal is to be left for quality control purposes. Examples could be the east face at Prince Colliery or extraction of the cleaner middle section of the thick Harbour Seam at the future Donkin-Morien Colliery.

.5 Soft Floor

Areas of soft floor occur in parts of the coalfield, including sections of Lingan and Prince Collieries. At Phalen, the floor can break up when a rider seam is less than 20 cm below the base of the seam. Horizon control systems have been shown to improve floor horizons under these conditions resulting in less dilution of the run-of-mine product.

.6 Hard Floor

Hard floors can lead to incendive sparking where they occur and any horizon control that reduces the possibility of picks striking the floor must improve safety standards.

.7 Gradients and Rolls

Rolls in the floor can change normal gradients from 8 - 10 degrees to as high as 25 degrees over a width of 30 m. Horizon control can have positive benefits under these conditions. Seam gradients are generally not a severe problem, but the early faces at Phalen are quite steep so any automation to counter the effects of creep that is developed for supports on AFC's may have an application here.

9.3 ROOF SUPPORT SYSTEMS

.1 Phalen Colliery

Phalen Colliery is fitted with Dowty two leg shield supports, equipped with the Dowty electro-hydraulic control system type B-2 button (MS14). To enable full utilization of the supports capabilities, the following facilities can be incorporated. By a software change in the Powered Support Control Centre (PSCC), infra-red support initiation may be achieved. This also requires the attachment of a transmitter on the shearer body work and receivers, individually addressed, attached to each support.

.2 Lingan and Prince Collieries

Both Collieries use Hemscheidt two leg shield supports fitted with standard hydraulic control systems. The retrofitting of these supports with electrohydraulic valve controls and an advanced control and condition monitoring system as installed at Phalen, would enable the benefits of such systems to be gained at these collieries.

The systems should be micro-processor based electrohydraulic system designed to give the benefits described in Section 3, improved speed of operation, better roof control with positive set, maximization of web depth, remote operation of supports with greater safety, improved reliability and ease of maintenance and better overall productivity through reduction in manpower and increased production.

The electrohydraulic system should be certified flame proof and/or intrinsically safe for underground coal mines by Energy Mines and Resources, Ottawa and meet the Labour Canada Safety Code.

The control system should be designed with a cycle time of 8 - 10 seconds and should achieve better than 95% of full web extraction.

The control system should be designed to operate with four levels of controls:

- Bi-directional automatic remote control.
- Bi-directional adjacent control.
- In-chock hydraulic control.
- Machine initiation.

The electrohydraulic control should have two automatic functions; support lower/advance/set and AFC push.

In the bi-directional automatic mode, the system should be capable of operating by an on-face single button where the advance or push cycles are operated by operation of a single button within a determined range. Alternatively, in free running sequence, the advance or push cycles will operate automatically through each support up to the operation position once initiated. The supports should be capable of being operated from the gate end for support set only.

The bi-directional adjacent control should have the functions; set both legs, set left or right leg in combination with an isolating valve, lower both legs, lower left or right leg in combination with an isolating valve and advance support.

The in-chock hydraulic controls via individual valve handles should include the functions; AFC push, set both legs, set left or right leg, lower both legs, lower left or right leg, advance support, extend and retreat stabilizing ram. A separate control should allow flaps to be extended or retracted.

The positive infra-red machine initiation system should be incorporated.

Full diagnostic systems should be provided in both the in-chock control unit and at the gate end computer. The gate end computer should provide information on the state of any support including leg pressures, supports that are not set, supports that are primed, disabled supports, log of faults and cable line faults. Consideration should be given to including a VDU to enhance display facilities.

The information available at the gate end computer should also be transmitted to the surface computer to allow remote monitoring and control from the surface.

Safety interlocks that are required include:

- Prevent two adjacent supports being lowered simultaneously.
- Prevent lowered supports pushing back into the waste.
- Prevent operators operating the support they are standing in.
- Ensure audible warning failure will disable a support.
- Ensure a support will only perform one function at a time.
- Ensure a primed support will have its own push buttons rendered inoperative.
- Ensure a support which has been primed manually cannot be initiated until a sufficient time delay has elapsed for the operator to move from the support.
- Ensure a primed signal cannot be transferred to a disabled support.
- Ensure a support cannot perform lower/advance/set function unless both adjacent supports are set.
- Ensure a support undergoing a lower/advance/set function.
- Prevent ghost operations.

.3 Cost

The capital cost of retrofitting a control system to a 100 m face as described above is estimated as:

Electrohydraulic controls	
65 supports at $10,000	$ 650,000
Gate end computer	100,000
Infra-red shearer initiation	
65 supports at $860 each	55,900
Transmitter	2,800
Face computer software changes	6,800
Support condition monitoring equipment	240,000
Total	$1,055,500

For a 210 m face, the cost would increase to approximately $1,870,000 (140 supports).

9.4 SHEARER CONTROL SYSTEMS

As Anderson Strathclyde shearers are in use on all CBDC longwall faces, it would be sensible to utilize, where applicable, Anderson's shearer control systems based on MIDAS as described in detail in Appendix 4A.

The MIDAS system incorporating the natural radiation sensor requires a definite interface between coal and roof strata where radiation levels differ sufficiently to allow its application. Also, the system requires roof coal to be left, which is part of its design parameters.

The MIDAS system incorporating the steering algorithm system (recognition system), has the advantage of being used where full seam extraction is required.

When irregular geological conditions are encountered, the operator can adjust the cutting height by remote control.

The requirement for manual adjustments must be recognized, especially in circumstances where sandstone intrusions, severe floor rolls, etc., are possible. This should not distract from the major benefits available, due to automatic horizon control, during the majority of operational time.

The Phalen shearers are designed to allow radio control to be fitted and it is suggested this be done once the new faces are established. This removes the operator from the immediate vicinity of the machine. However, an operator has still to be able to see and operate the trailing drum to control floor horizon. This would be eliminated by fitting a horizon control system, a constant extraction height or recognition system.

The shearers at Lingan and Prince, being of older design than the AM500, are difficult to retrofit for a horizon control system. The attachment of a MIDAS system, be it a natural radiation sensor or recognition type, would be unsatisfactory. At Prince, the system would not allow for health monitoring of the shearer, while at Lingan, the addition of an extra machine section would add another 1.2 m to the shoe distance of the machine.

The alternative is the purchasing of new machines, with installed horizon control system, rather than retrofit.

.1 Cost

Phalen	
MIDAS System (recognition type)	$ 197,000
Lingan/Prince	
Retrofit	Not recommended
New machines (including MIDAS) 2 @ $2,120,000	4,240,000
Total	$4,437,000

9.5 OTHER SYSTEMS

In the process of further automation at the CBDC collieries, the assessment of certain applicable systems needs to be mentioned. These may be still under trial or, as yet, not commercially available.

.1 Pick Force Guidance System

The system has undergone extensive trials within the U.K. at Cotgrave Colliery. Remodifications are on-going to transducers and transmission system. The potential benefits is the same as for the other form of horizon control, but its applications can be wider:

- Coalfaces where no roof coal is to be left.
- Coalfaces with a sandstone roof which does not emit sufficient natural gamma radiation.
- Coalfaces where the roof coal to be left is thicker than 500 mm, which is outside the range of the 801 natural radiation roof coal thickness sensor.
- Coalfaces where extraction is greater than 3 m and the use of a roof follower is impractical.
- Coalfaces where inconsistent levels of natural gamma radiation are caused by top coal being banded with shale.

.2 MACE

The Multi-purpose Automatic Control Equipment (MACE) has a wide application, its versatility can be of great advantage as it is being put forward to standardize "on machine" micro computer facilities.

The system can be used for MIDAS or pick force guidance horizon control, coal heading machines, face alignment and shield control.

.3 Expert System

The design of expert systems in analyzing machine failures is a great advance in obtaining expertise in problem solving. The system used by Anderson Strathclyde on shearers must be seen as a great advance.

With the availability of good health monitoring systems, a breakdown could be minimized by the use of these systems, to shorten any lost production by breakdowns.

.4 SUMMIT

The Supervisory Machine Monitoring and Information Terminal (SUMMIT) allows, by its software, displays of production and health monitoring of:

- Vertical and horizontal guidance systems for shearers.
- Coal heading machines.
- Road header and tunnelling systems.

In conjunction with a mine environmental monitoring system, it completes a comprehensive monitoring system in a surface control room.

9.6 TRAINING CONSIDERATIONS

CBDC have built up a skilled workforce who are readily adaptable to the demands of high technology equipment. The maintenance of the advance control systems is relatively simple consisting of unit replacement. Condition monitoring and diagnostic systems have made fault finding quicker and perhaps simpler. There is, therefore, no problem anticipated in training CBDC manpower to install and maintain advanced technology equipment. CBDC have the training capability in-house for this task.

The training program required for introduction of new control systems should consist of:

.1 Preparation of Training Material

Package of training information and visual aids covering the type of equipment to be used are prepared by instructors conversant with the management, installation, operation and maintenance of that equipment. The material is assembled to presentation by experienced instructors thereby ensuring that the person undergoing training can quickly and confidently get to grip with the technology. Strong emphasis is placed on the practical "hands-on" training as an integral part of the course.

.2 System Training

When equipment is delivered to the site, in accordance with the training plan, selected employees in groups which include both key operational personnel and potential trainers, undergo both theoretical and practical training.

.3 Operational Assistance

Experience has shown that it is essential to have operational assistance from system suppliers or knowledgeable consultants to guide the project personnel and ensure the systems are correctly installed and operate efficiently in the shortest possible time scale.

9.7 BENEFITS

.1 Manpower

Typical manpower at existing faces at Lingan and Prince are shown in the table below with potential manpower using the recommended systems.

	Prince	Phalen	Potential
Supervisor	1	1	1
Top End Men	3	2	2
Shearer Operators	2	1*	1
Panline Pusher	1	1	-
Support Operator	2	1	1
Bottom End Men	4	2	2
Console Operator	1	1	1
Mechanic	1	1	1
Electrician	1	1	1
Stage Loader Operator	1	1	-
Total	17	12	10

* Two if bi-drectional.

A saving at Lingan/Prince of 5 men/shift is possible or approximately $800,000/year/face.

Fewer men would be exposed to face conditions and the reduced manpower would operate in safer environment.

.2 Production

All experience with roof support and horizon control systems suggest that production and productivity increases particularly in poor roof and floor conditions.

Tests at Wath Colliery on similar faces showed an increase of over 40% in production rates.

An increase of only 10% in the face output of say, 3,000 t/d is equivalent to 300 t/d additional coal, which if valued at \$60/t represents a benefit of \$18,000/d or approximately \$4,000,000/y. This increased revenue, if attainable, would quickly repay the cost of system installation.

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
APPLICATIONS FOR THE SYDNEY COALFIELD

SECTION 10.0 - CONCLUSIONS AND RECOMMENDATIONS

TABLE OF CONTENTS

10.0 CONCLUSIONS AND RECOMMENDATIONS

- .1 INTRODUCTION
- .2 RECOMMENDATION FOR ROOF SUPPORT SYSTEMS
  - .1 Lingan and Prince Collieries
  - .2 Phalen Colliery
  - .3 Condition Monitoring of Supports
- .3 RECOMMENDATION FOR SHEARERS
  - .1 Shearer Systems
  - .2 Prince Colliery
  - .3 Lingan Colliery
  - .4 Phalen Colliery
- .4 ARMOURED FACE CONVEYORS
- .5 FURTHER RECOMMENDATIONS
  - .1 Surfaced Based Machine Monitoring System
  - .2 Expert Systems/Artificial Intelligence
  - .3 Coal Face Alignment
  - .4 AFC Monitoring
  - .5 MACE
- .6 CONCLUSIONS

REMOTE AND AUTOMATIC CONTROL SYSTEMS
FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL
APPLICATIONS FOR THE SYDNEY COALFIELD

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 INTRODUCTION

The majority of automation and remote control advances for longwall faces described in this report have been developed as individual applications. Combining several such sub-systems into an integrated system requires compatability of hardware and in certain cases, software and transmission highways.

Systems are not universally applicable and their application depends on local conditions.

Areas which will benefit from automation and remote control must be identified and the best available systems for the conditions incorporated at the collieries. They must be assessed on their reliability, suitability, ease of maintenance and cost effectiveness.

Certain problematical conditions cannot be overcome fully by automation and remote control. This may be due to unsuitable equipment and the unavailability of certain transducers to overcome site specific problems. The advances that can be achieved in obtaining a high percentage of automation can reduce the manpower from the coal face allowing the removal of the workforce from the area of highest health risk to a safer environment.

10.2 RECOMMENDATION FOR ROOF SUPPORT SYSTEMS

.1 Lingan and Prince Collieries

The Hemscheidt two leg shield supports should be retrofitted with electro hydraulic valve gear at these collieries. This allows the systems to be automated from a gate end computer system and the benefits of electro hydraulic support systems achieved. The installation would require the upgrading of the hydraulic power pack to the supports to approximately 300 l/min.

To further reduce manpower to initiate face supports, the installation of infra-red support initiation would be of benefit. The positioning of the shearer on the face would be more accurately fixed through use of this system.

The importance of the gate end support computer must be stressed in the use of these support control systems. The sophistication of the hardware and software requires that the highest standards are maintained and that the systems installed have been proven and are adaptable to change.

.2 Phalen Colliery

Phalen Colliery is already equipped with electro hydraulic shield supports and so little development in terms of automation is recommended at present.

The adjustment required to the Powered Support Control Centre (PSCC) should allow the application of infra-red support initiation to be achieved quite easily.

The software changes, transmitter and receivers would allow the removal of manpower for the operation of the shield supports.

.3 Condition Monitoring of Supports

The support control systems described remove face manpower and so increased reliance is placed on machinery which must be robust and not prone to failure.

Any automatic system without visual monitoring relies upon health condition transducers to obtain relevant information on the condition of machinery. Health monitoring, be it at the gate end or surface monitoring room, is a critical part of the automation process.

10.3 RECOMMENDATION FOR SHEARERS

.1 Shearer Systems

The earlier studies regarding automation and remote control of longwall mining, highlighted three main factors which needed to be fulfilled before any measure of automation of longwall becomes practicable, these being:

- Cutting horizon.
- Face alignment.
- Machine tilt.

Manufacturers have overcome much of the design problems with the shearer horizon control systems as regards cutting horizon and machine tilt.

The leaders of this application have been British; Anderson Strathclyde, BJD and Mining Supplies. The designs though, have tended to be marketed for European coal mine conditions, but as markets appear for the system outside of Europe, the development of suitable horizon control systems for world applications have been designed.

The natural radiation system would not be a suitable horizon control for CBDC mines, but the recognition type would offer the advantages of horizon control plus manual override to deal with major geological conditions. With these modifications, radio remote control would be advantageous for the machines.

.2 Prince Colliery

The Anderson Strathclyde AB16, 300 Hp, FIDD shearer at Prince Colliery would not allow the full application of the horizon control and health monitoring, by a MIDAS system, to be retrofitted.

The problem arises in regards the health monitoring system, which Anderson Strathclyde would not be able to apply to this machine.

The method of horizon control preferred is the steering algorithm system/recognition system, which has inherent advantages more suited to the CBDC Collieries.

The alternative solution is to replace the AB16 with an AM500, with horizon control fitted. The larger machine dimension of the AM500 can be overcome, if required, by underframe adjustments. Radio remote control would be required to obtain the full benefit from the alternate choice of machine, if purchased as a replacement.

.3 Lingan Colliery

Lingan Colliery is equipped with an Anderson Strathclyde AB16, 300 Hp type 27 Ambroas shearer. Here again, modifications to the machine is made difficult by the necessity of adding an extra machine section to the shearer to allow a MIDAS system to be retrofitted.

The recognition version of MIDAS is recommended, but the difficulty would be the added 1.2 m of machine length over the shoe distances.

Alternatives to this problem are to purchase a machine with a fitted horizon control system or the Mining Supplies Pathfinder, which is under development for double drum machines. This system bolts onto the shearer due to its power take off unit that allows modules to be fitted instead of a machine section. The system is also designed to operate for a recognition mode.

At present, alternatives are the Anderson Strathclyde retrofit or a replacement machine. While other manufacturers are under trial with their double drum steering system, Anderson Strathclyde has it available on the market. Radio remote control at the colliery would also require a new machine, but from a safety aspect, it is not recommended by the shearer manufacturer in this seam or restricted heights.

.4 Phalen Colliery

Phalen Colliery is equipped with an Anderson Strathclyde AM500 shearer. The retrofitting of the machine is to recognition steering system would be beneficial. The use of radio remote control system would allow the system to operate at its full potential.

The recognition system has been applied by Anderson Strathclyde successfully at West Cliff Collliery, Australia (Section 4.3) and is now being adopted as a method of full seam extraction horizon control by other manufacturers.

10.4 ARMOURED FACE CONVEYORS

The AFC capacity is critical to a fully automated coal face. As coal clearance became more critical with mechanized mining, so it grows in importance in relation to automated mining systems.

The decrease in support cycle time in conjunction with high powered shearers allows high cutting speeds to be achieved.

The AFC at Phalen, rated at 1000 t/h, is adequate for the production achieved at the mine, but Lingan and Prince will require the re-assessment of the coal clearance system to meet the development of the automated systems employed at the collieries.

Modern AFC capacities of 1200 t/h to 2000 t/h are installed on high technology faces with motor sizes up to 500 kW. The AFC at Lingan with a 600 t/h capacity, would restrict output from an automated face. This logic follows through to the stage loader and belt systems.

10.5 FURTHER RECOMMENDATIONS

.1 Surfaced Based Machine Monitoring System

Although not commercially available, there is a requirement for a system of machine and production monitoring such as British Coal's Supervisory Machine Monitoring and Information Terminal (SUMMIT).

The monitoring system would allo the following information to be displayed at a surface station:

- Face alignment.
- Shearer horizon and position.
- Health monitoring of machines.

The system of surface monitoring should be done on a fully integrated system and should be expandable to incorporate further automation systems or techniques that may be employed in the mine. This required standardization of software and hardware to enable the full exploitation of the system.

.2 Expert Systems/Artificial Intelligence

Many researchers believe that the use of expert systems can lead to a fully automated industry. Its use in the mining industry, such as British Coal's Headquarters Technical Department "Shearer" expert system, for diagnosis of faults on the Anderson Strathclyde AM500 shearers, can eventually lead to further applications.

By analyzing the symptoms and concluding an answer to a breakdown, the time saved in initially searching to find the fault or faults would reduce machine down time and repair time spent on the coal face.

.3 Coal Face Alignement

Face alignment has been identified as a critical area in allowing the advancement of automation to coal faces.

Work has been done to allow face alignment to be monitored and corrected.

The cord transducer system can be interrogated by a gate end monitor, where a tabular list of readings or graphical profile is displayed. An alternative under trial is the analog transducer to measure ram push.

.4 AFC Monitoring

AFC routine condition monitoring system can be incorporated into the total system by being integrated into the support condition monitoring system.

Information available for monitoring are voltages, power and current. This would be displayed by tabular or graphical display. Also available would be transducers for measurements of oil debris and temperatures.

Consideration must be given to a development linking the control of the shearer speed based on AFC load. This would allow for efficient coal cutting and loading and reduce peak loads, which is a great advantage.

.5 MACE

The need to allow for flexibility within the total automated system requires standardizing on hardware and in cases, software to allow incorporation of future developments to the system. If the total system is not formulated in this way, any expansion would become costly and unattractive.

The fundamental concept of MACE is to fulfill a wide variety of monitoring and control applications without recourse to the redevelopment of basic monitoring software. A basic monitoring system has therefore been developed around the monitoring and communications boards which is independent of the application.

The system has high integrity due to each individual intelligent unit having the capability to operate independently so the risk of total system failure is minimized. Its range of applications are:

- Shearer vertical guidance systems.
- Horizontal guidance, face alignment.

This illustrates the system's inherent value and versatility.

10.6 CONCLUSIONS

The development work carried out by manufacturers' research organization and operators over the years has brought the goal of a fully automated coal face a little closer. Developments have allowed the reduction in manpower required on the coal face. The achievements have been accomplished at a steady rate and while most of the manufacturers are based in Western Europe, the U.S.A., Canada and Australia have been the leaders in implementing this technology.

The three areas identified as being critical in achieving remote and automatic control of cutting machines are cutting horizon, face alignment and machine tilt.

All but the first have been effectively adapted to varying world wide conditions. The flexible control of cutting horizon to allow a shearer to work unattended has yet to be fully solved. An operator is still required for manual recognition of severe geological conditions and to assess general coal face operations.

The wide use of computers, artificial intelligence, transducers and remote control will allow the manless coal face to become a reality in the not too distance future.

The current need is to develop a total system with standardized features yet flexible enough to incorporate additional levels of automation as they are developed.

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

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VOLUME 2 - APPENDICES

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APPENDIX A

ROOF SUPPORT CONTROL SYSTEMS

DOWTY
WESTFALIA/SIEMENS
EICKHOFF
KLOECKNER-BECORIT
HEMSCHEIDT
GULLICK

DOWTY

ELECTRONIC CONTROL SYSTEM TYPE B — 2 BUTTON (MS14)

(4TH. EDITION)

DOWTY MINING EQUIPMENT LIMITED
ASHCHURCH · GLOUCESTERSHIRE GL20 8JR · ENGLAND

Telephone: Tewkesbury 0684 292441
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Telegrams: "Dowty's, Tewkesbury, Telex"

DOWTY ELECTRONIC CONTROL SYSTEM
TYPE B - 2 BUTTON
(MS14)

CONTENTS

Section — Page

1. INTRODUCTION — 3
2. CONTROL EQUIPMENT — 3
3. SUPPORT OPERATION — 6
4. SUPPORT INITIATION — 7

Lists of Parts

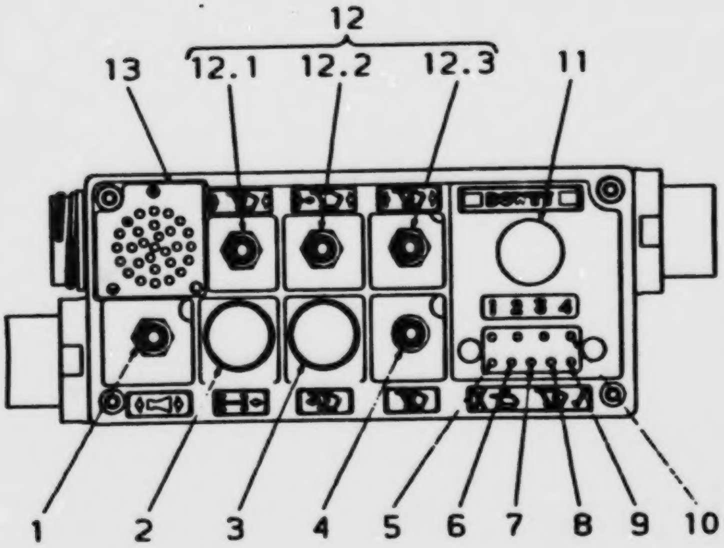
Block diagrams (typical) — 15

GLOSSARY TECHNICAL TERMS — 21-23

Illustrations

Figure — Page

1. Chock interface unit (typical) — 2
2. Powered support control centre (typical) — 4
3. Operator position for conventional bi-di working (typical) — 5
4. Operator position for one web back working (typical) — 6
5. Support exclusion — 8
6. Block diagram (S.I.U. type) typical — 14
7. Block diagram (L.S.U. type) typical — 14
8. Electrical diagram - system (S.I.U. type) typical — 16
9. Electrical diagram - system (L.S.U. type) typical — 17
10. Supply interlock unit (typical) — 18
11. Lockout supply unit (typical) — 19
12. Electrical diagram - Dowval pack (typical) — 20



1	PRIME/DIRECTION SWITCH
2	CONVEYOR ADVANCE BUTTON
3	SUPPORT ADVANCE BUTTON
4	NORMAL/DISABLE SWITCH
5	FAULT INDICATOR SWITCH
6	SUPPORT LOWERED INDICATOR (YELL
7	PRIMED SUPPORT INDICATOR (RED)
8	SUPPORT ADVANCED MONITOR (YELLOW)
9	SEQUENCE 'HEALTHY' INDICATOR (GREEN
10	SOLENOID INDICATORS (YELLOW)
11	LOCKOUT BUTTON (EMERGENCY STOP)
12	ADJACENT CONTROL SWITCHES:
12.1	POWER LOWER
12.2	SUPPORT ADVANCE
12.3	SUPPORT SET
13	AUDIBLE WARNING UNIT

FIGURE 1 CHOCK INTERFACE UNIT (TYPICAL)

DOWTY ELECTRONIC CONTROL SYSTEM

TYPE B - 2 BUTTON

(MS14)

1. INTRODUCTION

1.1 The Dowty electronic control system type 'B' is approved by British Coal and is certified intrinsically safe by the relevant British Authorities - certificate number 11264. In this system, the lockout (emergency stop) control lines are fed along the chock control system cables and the lockout circuits and stop buttons are incorporated in each Chock Interface Unit (C.I.U.).

1.2 A Chock Interface Unit (C.I.U.) is fitted to each support and houses the support controls and indicators. System electrical power from the gate end power supply unit is fed via a Supply Interlock Unit (S.I.U.) or Lockout Supply Unit (L.S.U.) depending upon the installation, to a face end controller designated the Powered Support Control Centre (P.S.C.C.). The P.S.C.C. is connected electrically to the C.I.U.'s by multi-core cables and supervises the remote operation of the face.

1.3 The P.S.C.C. is an intelligent (micro-processor-based) face end unit used to receive, interpret and execute operator requests which are then transmitted via the electro-hydraulic interface to perform various functions within the Dowval electro-hydraulic system. An installation using C.I.U.'s in conjunction with a P.S.C.C. is designated system type B.

1.4 Each Chock Interface Unit has a lockout button which when operated, halts all electrical operation of the face. Simultaneously, a solenoid operated dump valve situated at the gate end is activated to dump the face pilot pressure or main pressure (depending on installation requirement) to return and to cut off the pump supply to the face.

1.5 Two electrical supplies (nominally 12 V dc) are used to power the type B system and are designated supply A and supply B. Supply A is used to power the chock control circuits and lockout circuits along the face and is routed through the P.S.C.C. Supply B is used to power the P.S.C.C. circuits and the dump valve.

1.6 The equipment provides two forms of control, both operative from within the face supports, allowing the operator to obtain the following functions:-

a) Independent, bi-directional, on face push button electronic control for sequential operation*.

b) Bi-directional, adjacent electrical control of support power lower, support advance and support set when face conditions do not permit full sequential operation.

1.7 The following (optional) forms of control can also be included:-

a) Free running push button control.
b) Remote manual control.
c) Machine initiation for support and conveyor advance operations.
d) Bank push (face end supports).

Note: In-chock control is always available by manual operation of the Dowval module handles.

1.8 Audible and visual warning is given to the operator when any support is 'primed' (i.e. electronically prepared) and about to operate. Electrical interlocks provide extra safety during support operations. Other facilities include remote monitoring, timed delay positive leg setting and system fault diagnosis.

2. CONTROL EQUIPMENT

2.1 Chock Interface Unit (C.I.U.) Refer to figure 1

2.1.1 A C.I.U. is fitted to each support and is mounted, typically, in a position allowing easy access to the controls. Request signals originating from a C.I.U. are routed via multi-core cables to the (P.S.C.C.) at the gate end. If interlock conditions are satisfied, the P.S.C.C. then returns the correct command signals to the next primed C.I.U. in the address sequence.

---

* Standard facility on type B system.

2.1.2 The C.I.U. is a sealed enclosure housing the support controls, electronics and indicator display. It also serves as a junction/distribution box for the in-chock and inter-chock cable assemblies. All electronic and adjacent electrical control is carried out from the C.I.U. using push buttons and toggle switches respectively.

2.1.3 Push button (2) **[yellow]** provides electronic control of conveyor advance and push button (3) **[blue]** controls support advance.

2.1.4 The 3 position, spring-biased-to-centre, toggle switches (12.1, 12.2 and 12.3) provide adjacent electrical control of support power lower, support advance or support set respectively in the left and right hand direction. **Note:** The adjacent control switches are 'hard wired' to their respective solenoid valves on the adjacent support and are not under the influence of the electrical interlocks, therefore they are true override controls and should be used with caution.

2.1.5 The manual priming operation (bi-directional) is controlled by toggle switch (1) which is 3 position spring-biased-to-centre.

2.1.6 The 'normal/disable' 2 position toggle switch (4) is stable in each position and is used to prevent a support from being controlled electronically. **Note:** The support can still be operated from one of the adjacent override controls. This switch can also be used to cancel unwanted prime signals.

2.1.7 The red lockout button (11) when depressed halts all support movement on the face by simultaneously interrupting the chock control electrical supply and the hydraulic supply to the face.

2.1.8 The C.I.U. front panel includes a 9 light monitor display and an audible warning unit (13) (refer to sections 4.4.5 to 4.4.7 inclusive).

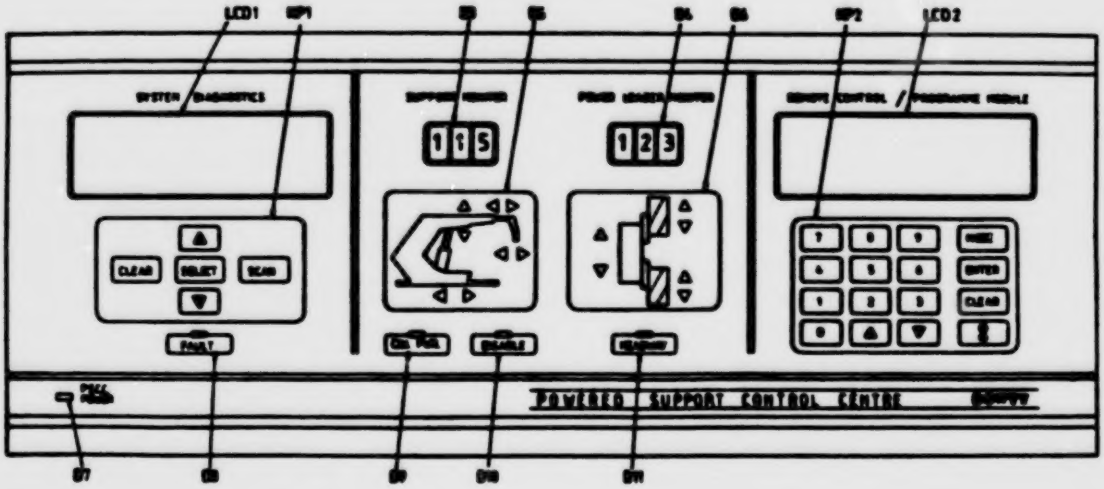


FIGURE 2 POWERED SUPPORT CONTROL CENTRE (TYPICAL)

2.2 Powered Support Control Centre (P.S.C.C.) Refer to figure 2

2.2.1 This programmable face end controller is a sealed enclosure housing the microcomputer, its associated displays and switches. It also serves as a junction/distribution box for the face data communication and power supply cable assemblies. The P.S.C.C. is powered from either the supply interlock unit or a lockout supply unit depending upon the installation.

2.2.2 The front panel is sub-divided into three distinct areas. The left hand side contains the keypad and liquid crystal display for system diagnostics. The centre contains the mimic displays digital counters and indicator lights for support monitor and power loader monitor. The right hand side contains the keypad and liquid crystal display for remote control and programme module including a running log.

2.2.3 The P.S.C.C. provides the operator with constantly updated, detailed information about support operations, individual support conditions (and machine status, if required). Fault conditions are displayed automatically, otherwise the keypads are used to obtain additional information. Changes to the working parameters (by authorized personnel) can also be made via a keypad. **Refer to separate P.S.C.C. technical brochure.**

2.3 Dowval Pack (Electrical Equipment) Refer to figure 12

2.3.1 The electro-hydraulic interface is provided by an intrinsically safe solenoid valve/pressure switch assembly housed under a protective cover on the Dowval pack. Refer to technical brochures 129280-00-38 (Solenoid Valve) and 125576-00-60/52-67 (Pressure Switch).

2.3.2 In the following typical example, four solenoid valves and two pressure switches* are used, their functions are:-

Valve 1	Leg set
Valve 2	Power lower
Valve 3	Conveyor advance
Valve 4	Support advance

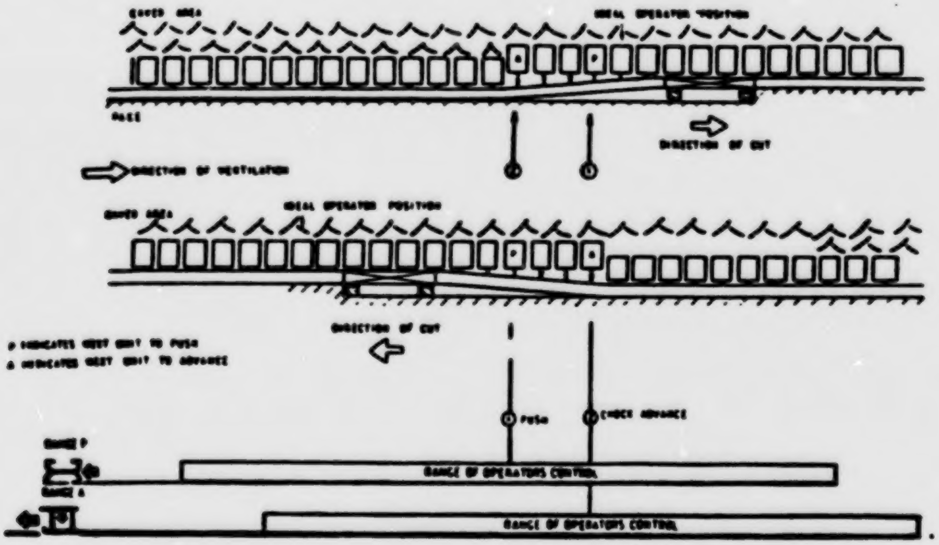

CAVED AREA
IDEAL OPERATOR POSITION
FACE
DIRECTION OF CUT
DIRECTION OF VENTILATION
CAVED AREA
IDEAL OPERATOR POSITION
DIRECTION OF CUT
P INDICATES NEXT UNIT TO PUSH
A INDICATES NEXT UNIT TO ADVANCE
PUSH
CHOCK ADVANCE
RANGE P
RANGE OF OPERATORS CONTROL
RANGE A
RANGE OF OPERATORS CONTROL

FIGURE 3 OPERATOR POSITION FOR CONVENTIONAL BI-DI WORKING (TYPICAL)

2.3.3 **Pressure** switch 1 operates when pressure in one of the front legs reaches a pre-determined value.

Pressure switch 2 receives a hydraulic signal and operates when the support has advanced to within a pre-determined distance from the fully advanced position.

2.4 Cable Assemblies (Refer to figures 6 and 7)

2.4.1 The type B control system uses the following typical cabling arrangement:-

a) An in-chock cable connects the chock interface unit (C.I.U.) to the Dowval pack.

b) An interchock cable connects the C.I.U.'s of adjacent supports.

c) A series of roadway cables connects the first support on the face to the (P.S.C.C.).

*** Note: Certain installations require the use of four pressure switches. Refer to Appendix B of the Powered Support Control Centre technical brochure.**

d) A pair of cable assemblies connects the L.S.U./S.I.U. to the P.S.C.C.
e) A dump valve cable connects the dump valve to the L.S.U./S.I.U.
f) A cable assembly connects the P.S.C.C. to the machine information output connector (optional).

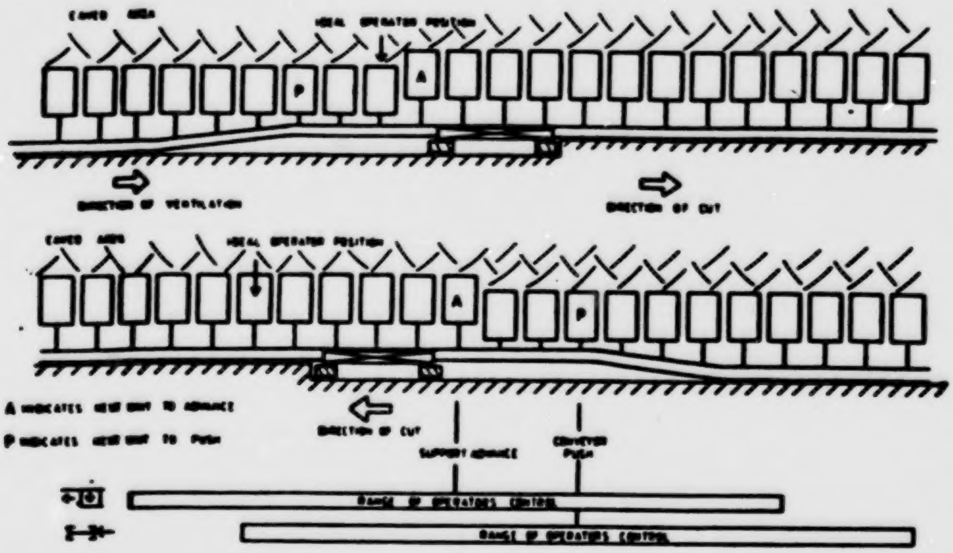

CAVED AREA
IDEAL OPERATOR POSITION
P
A
DIRECTION OF VENTILATION
DIRECTION OF CUT
CAVED AREA
IDEAL OPERATOR POSITION
A
P
A INDICATES NEXT UNIT TO ADVANCE
P INDICATES NEXT UNIT TO PUSH
DIRECTION OF CUT
SUPPORT ADVANCE
CONVEYOR PUSH
RANGE OF OPERATORS CONTROL
RANGE OF OPERATORS CONTROL

FIGURE 4 OPERATOR POSITION FOR ONE WEB BACK WORKING (TYPICAL)

3. SUPPORT OPERATION

3.1 The following sections describe the operation of supports used in a typical installation. Support advance and conveyor advance is controlled by a single operator.

3.1.1 Conventional Bi-Directional Working

The initial condition for conventional bi-directional working is with the support advanced to the conveyor. The sequence of operations when the machine has passed is then as follows:-

a) Advance conveyor.
b) Advance support and set legs.

3.1.2 Figure 3 shows the ideal operator's position for left or right hand working, enabling the operator to be positioned on the clean air side of the machine.

3.1.3 One Web Back Working

The initial conditions for one web back working is with the conveyor advanced to the face and the supports set one web back from the Armoured Flexible Conveyor (A.F.C.). The sequence of remote operation is then as follows:-

i) When the machine has passed, release, advance and reset the support.
ii) Advance the conveyor.*

Figure 4 shows the ideal operator postion for left or right hand working enabling the operator to be positioned on the clean air side of the machine.

3.2 Sequential Operation

3.2.1 The support from which the sequence is to commence must be 'primed' manually for the function required. The operation of an ADVANCE button will then cause the next support in sequence to release, advance and reset. Operation of a PUSH button will cause the next advancing ram in sequence to lock-on push hydraulically and advance the conveyor. Once a support has completed its function, its 'primed' signal will be cancelled and transferred to the next unit provided that this unit is not disabled or faulty. This unit will then be ready to respond to an initiate request from any support within its control zone or range. The range is deliberately restricted to ensure that push buttons outside the area of operations cannot initiate supports within the working area. This range may be different for each function up to a maximum of 30 supports and may be set on the P.S.C.C. by authorized personnel.

---

* Note: Bank push (main gate) is available as an option on certain installations. This facility also affects the starting sequence. Refer to Appendix 'D' of the technical brochure 'Powered Support Control Centre'.

3.2.2 With the exception of support advance, all sequenced support operation consists of the timed energisation (programmable in the P.S.C.C.) of the respective solenoid valve. The support advance cycle timing is mainly under the control of the 'advance' and 'set' pressure switches but is also supervised by the P.S.C.C. as it continuously interrogates each C.I.U. status. The prime signal will be transfered after 'support set' is sensed but the 'set' solenoid will continue to be energised for a further period (also programmable) to ensure positive leg setting.

3.3 Starting The Sequence From The End Of The Face (Refer to figures 2, 10, 11)

3.3.1 Start the power pack and check that it is delivering the correct pressure. Switch on the gate end power supply to the L.S.U./S.I.U. **Note:** The L.S.U. has its own mains isolator switch and neon indicator. Move the P.S.C.C. power switch to the ON position this will power-up the computer. Move the C.I.U./FACE switch to the ON position. The unit will sound its audible warning and red warning lights will appear on the fault panel. **Note:** On installations using a S.I.U. there are two switches for power to the P.S.C.C. and C.I.U.'s. These switches must be in the ON position to allow the system to power up correctly. Depress the green RESET button on the L.S.U./S.I.U. The warning lights should extinguish and the audible warning cease to sound. An indicator light will glow on the front panel of the powered support control centre in the P.S.C.C. POWER position and in the C.I.U. POWER position if face power is present. If face power is not present, the indicator light in the C.I.U. POWER position will not be illuminated.

3.3.2 Before any support can be operated electronically it must first be 'primed' (i.e. electronically prepared) to operate on receipt of a push button signal from any support within range. This preparation or priming is normally achieved automatically by the adjacent support, when the adjacent support has completed its cycle. In this way, operating sequences are allowed to move through the face by causing the 'sequenced' support to prepare the next unit for push button activation.

3.3.3 Support priming is always accompanied by an interrupted tone from the audible warning on the primed C.I.U. together with a flashing red light on its display panel so that operators are made aware of the next support to be activated. Manual priming is required for starting the operating sequence and is achieved as described in the following section.

3.4 Support Advance (Refer to figure 1)

3.4.1 On the support to be primed, move the prime switch (1) ←▮◀→sideways in the direction that the sequence is to proceed. This position must be held, since the switch will return to the normal central position if released. When the prime position is selected, operation of the BLUE support advance button (3) will prime the C.I.U. for support advance. The prime switch and push button can now be released.

3.5 Conveyor Advance

3.5.1 The procedure is exactly the same as that described in support advance except that the YELLOW conveyor advance button (2) is depressed when the prime position is selected.

Note: The prime signal (audible warning and flashing light (7) can be cancelled if required by moving the 'run/disable' switch (4) downwards to the ✷ position and then upwards to the 'run' position. This action cancels the prime condition.

4. SUPPORT INITIATION

4.1 Support Advance (Refer to figure 1)

4.1.1 When the first support has been primed manually, a time delay of 8 seconds must elapse before the support can be initiated. This delay is introduced to allow the operator to move to the safety of another support before the primed support can be operated. This delay will start following each manual prime during which time none of the support functions are capable of being started by remote initiation. When the time delay has expired, the operator can depress any BLUE support advance push button within range (but not that of the primed support). The 'power lower' solenoid is energised causing the canopy to lower from the roof. When the leg pressure switch senses a 'support lowered' condition, a timed delay (programmable in the P.S.C.C.) is started+. When the delay period has elapsed, the 'advance' solenoid is energised and the support advances with the legs continuing to lower. Pressure switch 2 operates when the support has advanced fully* and the 'power lower' solenoid is de-energised. The 'set' solenoid is energised causing the legs to extend. The 'support advance' solenoid remains energised. When the canopy makes contact with the roof and pressure in the leg line reaches 1450 p.s.i. (100 bar), pressure switch 1 senses a 'leg set' condition and allows the prime signal (audible warning and flashing light) to be transferred automatically to the C.I.U. on the adjacent support which will then respond to any BLUE push button within range. This pressure switch signal also causes the 'support advance' solenoid to de-energise but the 'set' solenoid remains energised for a further (programmable) period. During the setting operation the legs are fed via non-return valves and the final leg pressure will be equal to the maximum system pressure available at that time. A support which subsequently lowers will not automatically set to the roof unless set (electrically) by the operator.

* This facility allows the canopy to lower from the roof prior to commencement of support advance, providing sufficient clearance for base lifting to occur during soft floor conditions. **Refer to the technical brochure 'Powered Support Control Centre Appendix C' for fuller details.**

* When the support is almost fully advanced a striker valve inside the ram opens and transmits pressure (powering the ram) to the pressure switch 2 on the Dowval pack. The pressure switch is connected in turn to the C.I.U. which after a delay of approximately 0.8 seconds causes the 'advance' solenoid to be de-energised and the 'set' solenoid to be energised. When the advance solenoid is de-energised, the pressure transmitted through the striker valve decays to return.

4.2 Conveyor Advance

The procedure is similar to support advance as previously described. Any YELLOW 'conveyor advance' push button within range can be depressed. This will cause the 'conveyor advance solenoid to be energised for 2 seconds to pass an hydraulic signal to the conveyor advance module which then locks-on hydraulically causing the advancing ram to maintain continuous thrust against the conveyor. The audible warning and flashing light will cease to operate after approximately 2 seconds when the prime signal is transferred to the adjacent support. The next operation of a YELLOW conveyor advance button will cause the second support to advance the conveyor followed by the transfer of the prime signal with audible warning and flashing light to the third unit. In this way, supports can be engaged for conveyor advance every 2 seconds, but in practice, the button should be operated once on each support as the operator follows the machine through the face. This procedure will ensure that the conveyor 'snake' follows the machine at a safe distance.

Note: The sequence will be halted if the 'push prime' signal enters a support which is not set. An electrical interlock prevents conveyor advance on a lowered support.

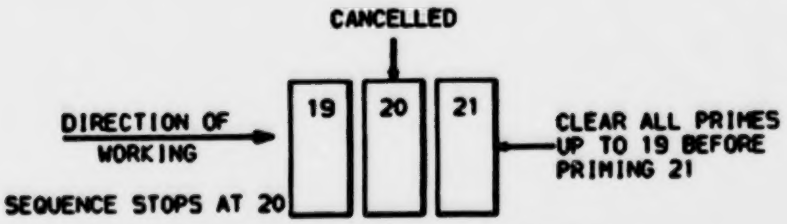


FIGURE 5 SUPPORT EXCLUSION

4.3 Exclusion of a Support

The 🔇 position of the DISABLE/RUN toggle switch is used for cancelling primes and for isolating the support electrically. With the switch in the 'disable' position, the solenoid supply is disconnected from the solenoid drive circuits and remote operation is not possible as the support is incapable of passing on prime signals. The 'disable' position can be used to halt a sequence at a pre-determined point on the face. In figure 5 support 20 is disabled so that the sequence of operations can proceed only so far as support 19. When the prime in support 19 has been cancelled, support 21 can be manually primed in order to continue the sequence. The audible warning and flashing light will not operate on a C.I.U. when its disable switch is in the 🔇 position.

Note:

a) An 'intitate' signal will pass through a disabled C.I.U. to operate any support within range that is primed for the same function.

b) A disabled C.I.U. is still capable of generating 'initiate' signals but cannot itself be manually primed.

c) When initiating from a disabled support, the (X), (↑▷), (→▷) and (✓) indicator lights will operate in the normal manner but the audible warning and flashing light (7) remains inoperative.

d) A disabled support is still capable of controlling an adjacent support via its override switches and can itself be controlled by the override switches of an adjacent C.I.U.

4.4 Electrical Adjacent Control (Refer to figure 1)

This facility allows the operator to control directly the solenoid valves on either of the supports adjacent to his own.

Note 1: Adjacent control is used in poor mining conditions where electronic control is unsuitable, or where failure occurs on a C.I.U. This facility should always be used to set adjacent supports which have been lowered off (**yellow L.E.D. glowing on the C.I.U. in the ↑▷ position**) [this is the disabling condition] enabling electronic control to proceed without interruption.

Note 2: Ensure that both adjacent supports are set before moving any support by means of adjacent control. This control must be used with care as it is routed directly to the solenoid valves and does not come under the influence of the P.S.C.C. i.e. the normal safety interlocks described in section 4.4.5 **DO NOT apply,** except for the lockout control.

4.4.1 Power Lower Adjacent Support

Move and hold toggle switch (12.1) ←▷→ in the required direction. The 'power lower' solenoid on the adjacent support will be energised whilst the switch is operated causing main pressure to be admitted to the annuli of the legs and the full area of the legs is connected to return simultaneously. The legs are power lowered. Movement ceases when the switch is released or the legs are lowered fully.

4.4.2 Advance Adjacent Support (Refer to figure 1)

The canopy should be clear of the roof. Move and hold toggle switch (12.2) ←←▷→ in the required direction. The 'support advance' solenoid on the adjacent support selected will be energised whilst the switch is operated causing the conveyor advance module to unlock and the support to advance. When the switch is released, all movement ceases and the switch returns to the central 'OFF' position.

4.4.3 Set Adjacent Support

Move and hold toggle switch (12.3) ←▷→ in the required direction. The 'set' solenoid on the adjacent support selected will be energised whilst the switch is operated causing main pressure to be admitted to the full area of the legs causing them to extend. Movement ceases when the switch is released or if the legs are set to the roof fully.

Note: Timed delay positive setting is not provided on adjacent control.

4.4.4 Operator Safety Instructions

a) DO NOT STAND IN FRONT OF **ANY SUPPORT** WHEN ITS AUDIBLE ALARM IS SOUNDING.

b) IN AN EMERGENCY **HIT ANY RED LOCKOUT BUTTON** TO STOP SUPPORT OPERATION THROUGHOUT THE FACE.

c) When a C.I.U. has been primed, it displays a flashing red light (7) on its monitor panel and the audible warning (13) sounds. If an operator is positioned in a support when this condition occurs and the support function is then initiated by another operator, the support function can be halted by depressing any push button on the C.I.U. The individual then has approximately 8 seconds to move to an adjacent support. The prime signal is not lost -which would be the case if the DISABLE switch or LOCKOUT button had been used. The operation can be restarted from the remote support by depressing a push button for the same function. **If in doubt, use the lockout button.**

d) If a situation occurs where a support fails to complete its cycle, move the RUN/DISABLE switch to the ✱ position to prevent electronic operation. The support can still be operated manually 'in-chock' using the Dowval modules or by adjacent control from the next support.

e) **REPORT** any mechanical or electrical defect to maintenance staff.

4.4.5 Remote Control Interlocks and Safety Features

Interlocks are provided to give the following safety features for push button operation:-

a) Depressing any red lockout button will halt all support operation until 'reset'. N.B. On installations where the dump valve is arranged to dump pilot pressure only, certain services (e.g. the advancing ram) will remain active.

b) Audible warning failure will disable a support

c) A support will perform only one function at a time.

d) A primed support will have its own push buttons rendered inoperative.

e) A support which has been primed manually cannot be initiated until a time delay (nominally 8 seconds) has elapsed.

f) A prime signal cannot be transferred to a disabled support.

g) A support cannot perform a lower/advance/set function unless both adjacent supports are set.

h) A support undergoing a lower/advance/set function must complete that function within a pre-determined perod.

j) A lowered support cannot perform a conveyor advance function.

k) Holding a push button down will not cause sequences to 'jump' through the face. Too short a push will be ignored by the P.S.C.C.

l) Repeated operation of a push button will not cause automatic initiation of the next support in sequence.

m) A faulty push button (stuck fault) will not affect the operation of other push buttons.

n) A working support will be halted by the operation of any push button on its C.I.U.

4.4.6 Chock Interface Unit Monitor Display (Refer to figure 1)

When a primed support is initiated, yellow light emitting diodes (L.E.D.'s) in positions 1, 2, 3 or 4 are illuminated to confirm when a particular solenoid is in the energised condition. These L.E.D.'s are used to check the correct functioning of a sequence of events.

Position 1 = Set solenoid 1 energised.
Position 2 = Support advance solenoid 2 energised.
Position 3 = Conveyor advance solenoid 3 energised.
Position 4 = Power lower solenoid 4 energised.

The response by the primed support to the operation of push buttons is also monitored. The green L.E.D. (9) on the C.I.U. monitor panel will illuminate together with a continous tone from the audible warning to inform or alert the face operator. On a disabled C.I.U. the green L.E.D. will not be accompanied by the audible warning tone. The signalling codes are as follows:-

a) The green L.E.D. illuminates for 1 second and there is a 1 second 'bleep' from the audible warning when an initiate button is pressed. This signal indicates that the support primed for that function has received a 'start' command by the P.S.C.C.

b) A short flash (½ second) by the the green L.E.D.) accompanied by a ½ second 'bleep' from the audible warning indicates that the button has been pressed too early (i.e. the system is 'busy'). This means that:

- i) The pre-start period following a manual prime has not yet expired, or
- ii) The previous support has not yet completed its function, or
- iii) The function sequence is operating under machine control.

c) Two short flashes (½ second) together with two ½ second 'bleeps' from the audible warning following response (ii) above indicates either that the pre-start period has now expired or the next support is primed ready for operation. This signal will only be given on the support on which the 'busy' signal has been received i.e. the last operated buttons.

d) The green L.E.D. is illuminated for a 3 second period together with a 3 second 'bleep' from the audible warning when a push button is pressed in the (optional) free running, push button mode. This signal indicates that the support primed for that function has received a 'start' command from the P.S.C.C. and that the function will continue the free run up to the operator's support unless stopped by futher action. This signal will only occur when the P.S.C.C. is set for the free running mode of operation. **Refer to separate Powered Support Control Centre brochure for further details.**

e) The green L.E.D. is illuminated for a 5 second period together with a 5 second 'bleep' from the audible warning when a push button is pressed in the (optional) machine initiation mode which corresponds to a second primed function. If the button corresponds to a function which is primed but not 'second primed', then the response is a ½ second tone.

4.4.7 Fault Conditions

a) If the red fault L.E.D. (5) illuminates for 1 second when an initiate button is pressed then one of the following conditions has occurred:-

- i) The next support to operate is disabled,
- ii) The interlock conditions are not satisfied for the primed support.
- iii) The previous support has not completed its support advance function due to a fault condition.
- iv) A fault condition has occured on the next support to operate e.g. communication failure or audible warning failure.

b) If the command is not accepted for any other reason than those listed above e.g.if the operator is out of range of the primed support for the function in question or there is no prime present for that function, then neither the green L.E.D. or the red L.E.D. will be illuminated.

c) A YELLOW L.E.D. (6) in the ↶ position will be illuminated when the leg pressure switch indicates that the support is lowered. For safety reasons a support is not permitted to move unless both adjacent supports are set. If 'lowered' supports are present on the face, the support advance sequence will stop at the support adjacent to the lowered support. This indication allows the operator to detect and set lowered supports which would otherwise interrupt normal sequential operation.

d) A YELLOW L.E.D. (8) ➢ illuminates during normal sequential operation to confirm the correct operation of the advancing ram pressure switch. Certain ram and ram pressure switch fault conditions, will cause this L.E.D. to glow continuously.

4.5 Powered Support Control Centre (P.S.C.C.) [Refer to figure 2]

The P.S.C.C. control panel is sub-divided into three distinct areas: System diagnostics, support monitor/power loader monitor and remote control/programme module.

4.5.1 System Diagnostics Panel (L.C.D.1, KP1)

Diagnostic information is presented in plain English on a liquid crystal display (L.C.D.). An operational or system fault ocurring during normal running is announced automatically by the illumination of a red flashing FAULT indicator. Details of the fault condition is also written into the display (L.C.D.2). A fault is simultaneously registered on the operator's support by the illumination of the fault monitor L.E.D. on that C.I.U. System fault indications include the following:

a) Cable/line fault (location).
b) Chock interface fault (location).
c) Power loader fault
d) Sequence stoppage due to disabled supports (location)
e) Sequence stoppage due to lowered supports (location).
f) Sequence stoppage due to timeout conditions (location).

Display (L.C.D.1) can also be driven from the keypad (KP1). Operation of the SELECT key will produce a 'menu' of support conditions for examination by the operator. This menu includes:

a) LOWERED SUPPORTS
b) DISABLED SUPPORTS
c) ► PRIMED SUPPORTS
d) FAULT LOG
e) LINE FAULT SCAN

In the example shown below, for primed supports, a typical display would be:

```
PRIMED                12:30

 Zone          1       2

 Push         10↑

 Advance              20↓
```

i.e. Support 10 is primed for push 'up' the face (e.g. to a C.I.U. with a higher address number). No other primes exist in Zone 1.

Support 20 is primed for advance 'down' the face (e.g. to a C.I.U. with a lower address number). No other prime exists in Zone 2.

This type of display can be extended for any form of diagnostics by simply adding to the menu. Further information can also be displayed by the provision of an asterisk on the screen (which appears automatically) when more pages of information are made available to the operator.

4.5.2 Support Monitor Panel (D3, D5)

The mimic display (D5) provides the status of the advancing support during normal conditions and its number appears at (D3). The display (D5) shows automatically the status of a support during fault conditions using illuminated arrows as follows:

a)	Support	advanced/not advanced
* b)	Support	set/lowered
* c)	Support	normal/disabled

* These indications are a standard provision.

4.5.3 Power Loader Panel (D4, D6)

When the power loader is fitted with a machine interface, this panel can provide the operator with the following information:

a) Machine position
b) Machine direction
c) Leading drum (raised/lowered) }
not usually available at the shearer
d) Trailing drum (raised/lowered) }
e) Headway fault

The HEADWAY indicator (D11) is illuminated automatically when the power loader-to-supports safety distance is outside the programmed limits. This interlock (which is dependent upon the limit exceeded) can invoke a 'holding' condition on either the power loader, or the support sequence. Failure of the power loader monitor system will stop operations and this condition will be indicated on the diagnostics panel. Note: Both the above conditions are only relevant when the modes selected are under automatic or machine initiated control.

4.5.4 Automatic Control/Programme Module Panel (L.C.D. 2, KP2)

This panel contains a liquid crystal display (L.C.D.2) and a keypad interface (KP2). These features provide on-site programme selection and programme modification by authorized personnel. For security reasons, all data changes must be accessed by the entry of a passcode. Personnel not knowing the code are permitted to examine the system parameters only and cannot change them. The choice of control method is selected from a menu presented on display (L.C.D. 2) following operation of the MODE key. A typical menu would be:

▶ MODE 1	On-face push button control
MODE 2	Free running push button control (if fitted)
MODE 3	Remote manual (if fitted)
MODE 4	Machine initiation (if fitted)

Note: Special precautions may be required when operating in mode 4 - refer to the technical brochure 'Powered Support Control Centre' (Section 6 - Machine Initiation).

The mode required may be selected by first moving a cursor arrow to the required position using the ▼▲ keys (KP2) and then pressing the ENTER key. In the example shown above, selection of MODE 1 would display the following data:

PUSH BUTTON CONTROL
PUSH RANGE - 20
ADVANCE RANGE - 10

Use of the cursor together with the ▼▲ keys would then allow changes to be effected in the control ranges as required. **Refer to the 'Powered Support Control Centre' brochure which contains full information about this unit.**

4.6 Lockout Supply System [Emergency Stop] Refer to Figures 6, 7, 10 and 11)

4.6.1 The system is used to interrupt the intrinsically safe electrical supply to the face, also to isolate the hydraulic supply between the pump(s) and the face and to decay the face hydraulic pressure, main or pilot (depending upon the installation) during an emergency. The power supply for the lockout system is derived from:-

a) A lockout supply unit+ (L.S.U.) with an integral intrinsically safe power supply, or,

b) A supply interlock unit+ (S.I.U.) which requires a separate intrinsically safe power source.

+ Refer to separate technical brochures for further information on these units.

4.6.2 The system is electrically independent of the chock control circuits although its power supply is derived from the same L.S.U./S.I.U. A separate supply conductor fed down the face is used to power a pulse generator housed within a Termination Unit at the remote end of the face. The pulsed output is routed back through the lockout buttons and via the P.S.C.C. to the L.S.U./S.I.U. A relay interlock system within the L.S.U./S.I.U. is used to interrupt face power supply A and de-energise the solenoid-operated dump valve.

4.6.3 During the lockout mode, a reduced voltage is fed down the face to provide power from the lockout monitoring circuits which enable the L.S.U./S.I.U. to locate the operated button. This information is then displayed in digital form by the lockout monitor.

4.6.4 Hydraulic and electrical power can only be restored to the face by resetting the affected lockout button i.e. by twisting its knurled edge in either direction, and by pressing the green reset button on the L.S.U./S.I.U.

4.6.5 The L.S.U./S.I.U. has its own mechanically latched 'push-pull' lockout button (red) and an audible warning active during a lockout condition.

4.6.6 Power supply A is continuously monitored by the L.S.U./S.I.U. and is automatically interrupted if it falls below a pre-determined level. Power can only be restored using the reset button if conditions are correct.

4.6.7 The pilot hydraulic pressure is also monitored by a pressure switch within the dump valve. Face supply A is interrupted if hydraulic pressure falls below a pre-determined level. Supply A cannot be restored until pressure is restored and the reset button is pressed.

4.6.8 A fault panel on the L.S.U./S.I.U. has 4 indicators which illuminate to indicate the following:

a) (Lockout 1) Pulsed signal D.C. level too low.
b) (Lockout 2) Pulsed signal frequency too slow.
c) Low pressure.
d) Low voltage.

4.7 Refer to the separate electronic control system diagnostics brochure for information on routine maintenance and electrical fault finding.

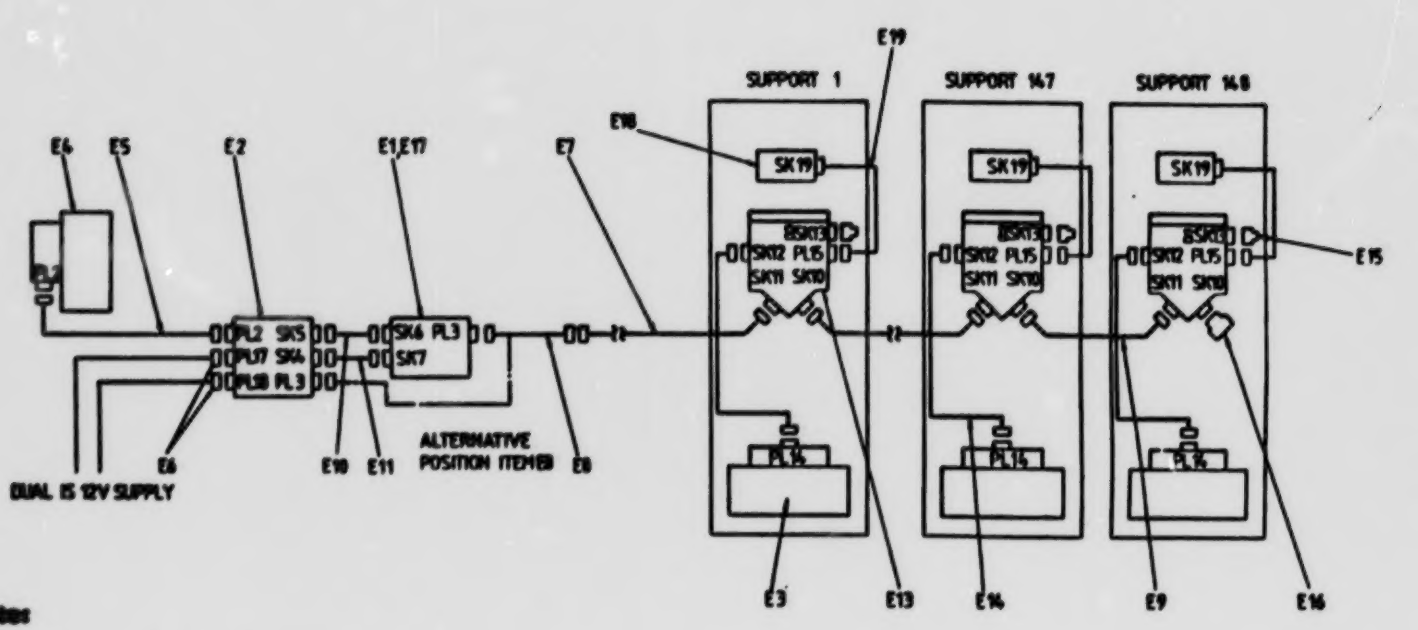

E4
E5
E2
E1,E17
E7
E18
E19
SUPPORT 1
SUPPORT 147
SUPPORT 148
SK19
SK13
SK12
PL15
SK11
SK10
PL14
PL2
SK5
PL17
SK4
PL18
PL3
SK6
SK7
E15
E6
E10
E11
ALTERNATIVE POSITION ITEM E8
E8
DUAL IS 12V SUPPLY
E3
E13
E14
E9
E16

FIGURE 6
BLOCK DIAGRAM
(S.I.U. TYPE) TYPICAL

Notes

Infra-red (machine initiation) is available on both S.I.U. and L.S.U. type systems.

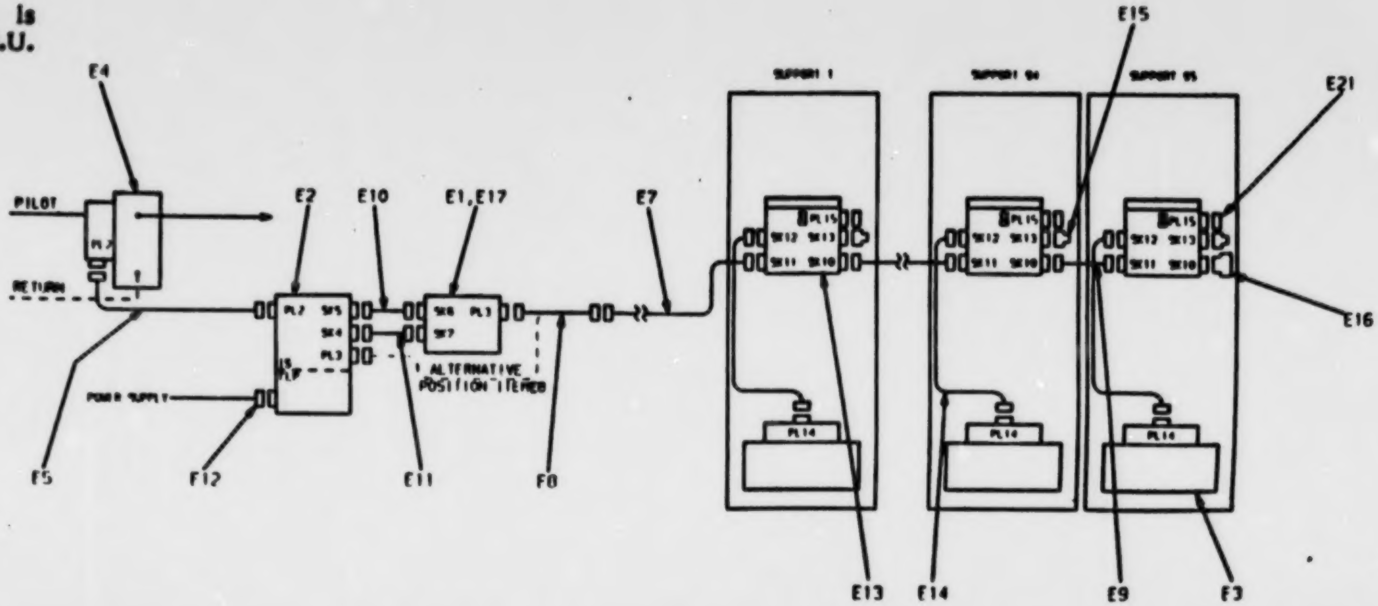

E4
PILOT
RETURN
PL2
E2
E10
E1, E17
E7
SUPPORT 1
SUPPORT 94
SUPPORT 95
E15
E21
PL15
SK12
SK13
SK11
SK10
PL14
SK5
SK4
PL3
SK6
SK7
ALTERNATIVE POSITION ITEM E8
POWER SUPPLY
E16
F5
F12
E11
F8
E13
E14
E9
F3

FIGURE 7
BLOCK DIAGRAM
(L.S.U. TYPE) TYPICAL

LIST OF PARTS SHOWN ON BLOCK DIAGRAMS (TYPICAL)

(Figures 6 and 7)

Item	Description		Quantity
E1	Powered Support Control Centre (P.S.C.C.)		1 Per Installation
E2	Lockout Supply Unit (L.S.U.) or Supply Interlock Unit (S.I.U.)		1 Per Installation
E3	Electro-Hydraulic Dowval Pack		1 Per Installation
E4	Dump Valve Master		1 Per Installation
E5	Dump Valve Cable		1 Per Installation
E6	4 Way Connector		2 Per Installation
E7	Roadway Cable 10m		1 Per Installation
E8	Roadway Cable 25m		As Required
E9	Inter-Chock Cable		1 Per Support
E10	Cable, Power Supply 'A'		1 Per Installation
E11	Cable, Power Supply 'B'		1 Per Installation
E12	Victor Plug		1 Per Installation
E13	Chock Interface Unit (C.I.U)		1 Per Support
E14	In-Chock Cable		1 Per Support
E15	Address Plug		1 Per Support
E16	Termination Plug		1 Per Installation
E17	Adaptor Plate (L.S.U./S.I.U.)		1 Per Installation
E18	Infra-Red Receiver (Optional)	Available on both S.I.U. and L.S.U. type systems	1 Per Support
E19	Infra-Red Cable (Optional)		1 Per Support
E21	Protective Plug		1 Per Support

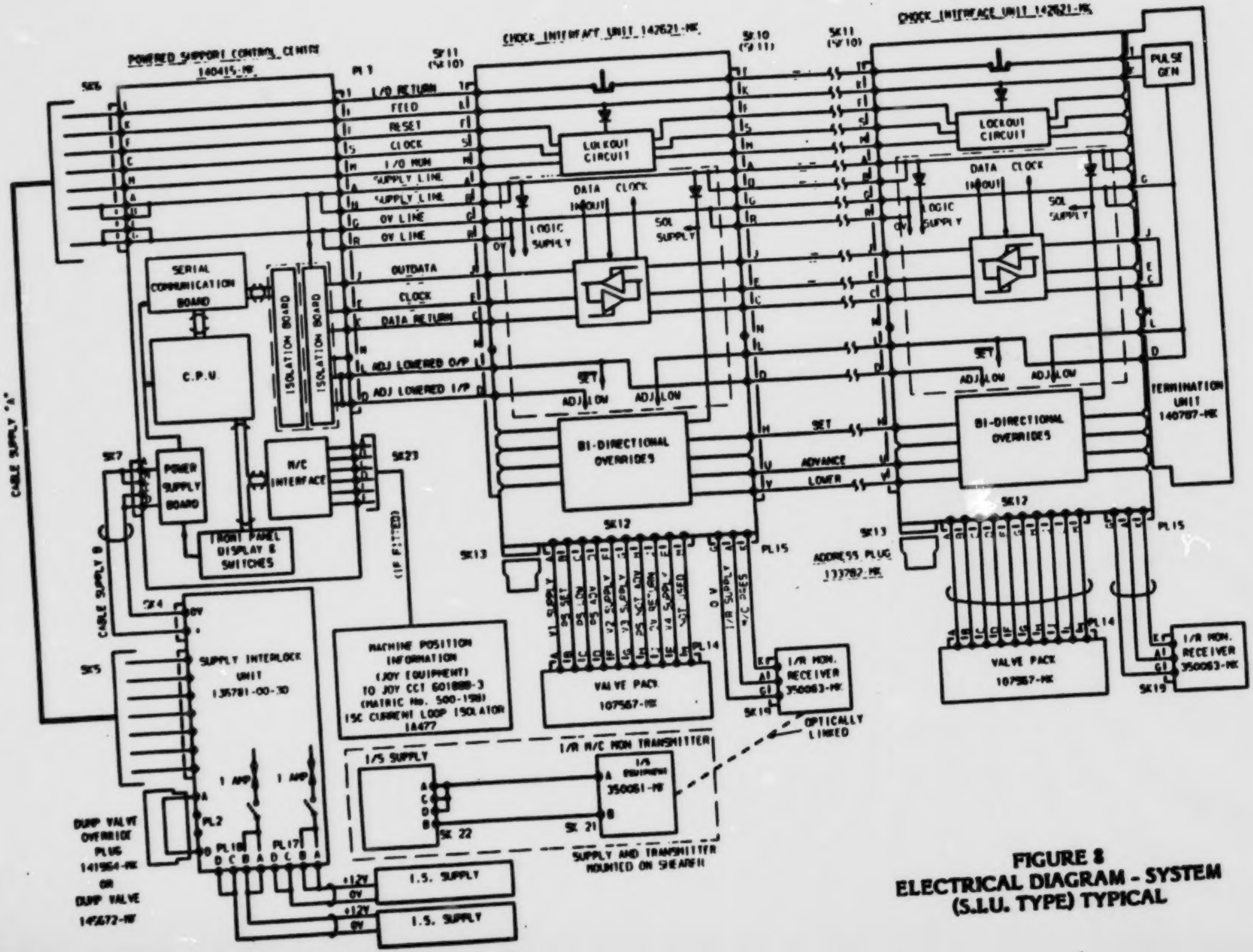

POWERED SUPPORT CONTROL CENTRE
140415-MK
CHOCK INTERFACE UNIT 142621-MK
CHOCK INTERFACE UNIT 142621-MK
SK6
SK7
SK5
SK4
SK11 (SK10)
SK10 (SK11)
SK11 (SK10)
PL1
I/O RETURN
FEED
RESET
CLOCK
I/O MON
SUPPLY LINE
SUPPLY LINE
0V LINE
0V LINE
OUTDATA
CLOCK
DATA RETURN
ADJ LOWERED O/P
ADJ LOWERED I/P
SERIAL COMMUNICATION BOARD
C.P.U.
ISOLATION BOARD
ISOLATION BOARD
POWER SUPPLY BOARD
M/C INTERFACE
FRONT PANEL DISPLAY & SWITCHES
SK23
(IF FITTED)
LOCKOUT CIRCUIT
LOCKOUT CIRCUIT
DATA
IN/OUT
CLOCK
LOGIC SUPPLY
SOL SUPPLY
0V
SET
ADJ LOW
ADJ LOW
BI-DIRECTIONAL OVERRIDES
BI-DIRECTIONAL OVERRIDES
SET
ADVANCE
LOWER
SK12
SK13
PL15
PL14
SK14
SK19
V1 SUPPLY
DS SET
DS LOW
DS ADV
V2 SUPPLY
V3 SUPPLY
DS NOT ADV
DS RETURN
V4 SUPPLY
NOT USED
I/R SUPPLY
0 V
M/C RECS
VALVE PACK
107567-MK
VALVE PACK
107567-MK
I/R MON. RECEIVER
350063-MK
I/R MON. RECEIVER
350063-MK
OPTICALLY LINKED
ADDRESS PLUG
133787-MK
PULSE GEN
TERMINATION UNIT
140787-MK
CABLE SUPPLY 'A'
CABLE SUPPLY B
SUPPLY INTERLOCK UNIT
135781-00-30
MACHINE POSITION INFORMATION
(JOY EQUIPMENT)
TO JOY CCT 601888-3
(MATRIC No. 500-198)
ISC CURRENT LOOP ISOLATOR
18477
I/S SUPPLY
I/R M/C MON TRANSMITTER
I/R
350061-MK
SK 21
SK 22
SUPPLY AND TRANSMITTER
MOUNTED ON SHEARER
1 AMP
1 AMP
PL2
PL18
PL17
D C B A
D C B A
+12V
0V
+12V
0V
I.S. SUPPLY
I.S. SUPPLY
DUMP VALVE OVERRIDE PLUG
141964-MK
OR
DUMP VALVE
145672-MK

FIGURE 8
ELECTRICAL DIAGRAM - SYSTEM
(S.I.U. TYPE) TYPICAL

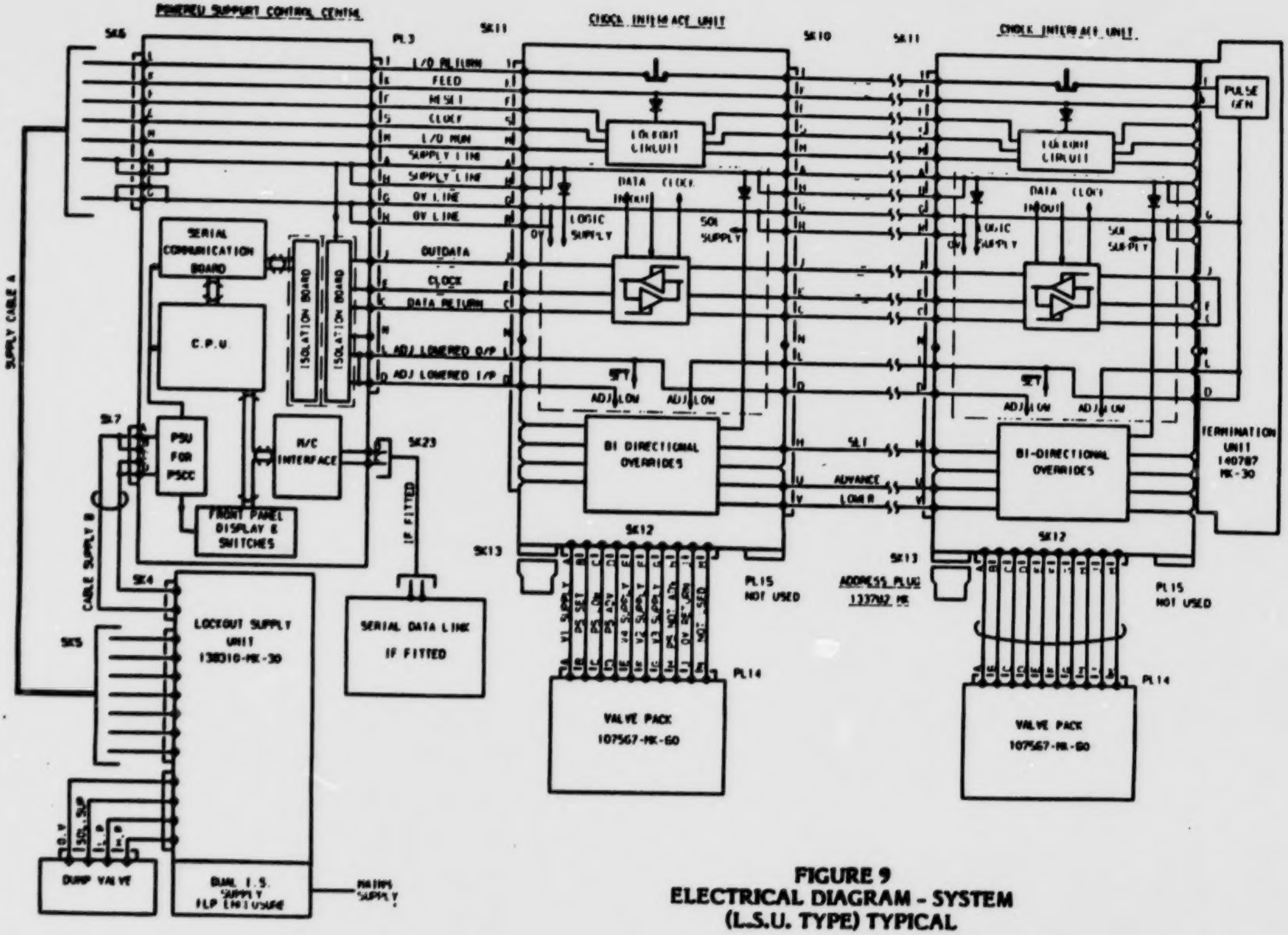

POWERED SUPPORT CONTROL CENTRE
CLOCK INTERFACE UNIT
CLOCK INTERFACE UNIT
SK6
PL3
SK11
SK10
SK11
L/O RETURN
FEED
RESET
CLOCK
L/O MON
SUPPLY LINE
SUPPLY LINE
0V LINE
0V LINE
OUTDATA
CLOCK
DATA RETURN
ADJ LOWERED O/P
ADJ LOWERED I/P
SERIAL COMMUNICATION BOARD
C.P.U.
ISOLATION BOARD
ISOLATION BOARD
PSU FOR PSCC
R/C INTERFACE
FRONT PANEL DISPLAY & SWITCHES
SK7
SK23
SK4
SK5
SUPPLY CABLE A
CABLE SUPPLY B
IF FITTED
SERIAL DATA LINK IF FITTED
LOCKOUT SUPPLY UNIT 138010-MK-30
DUAL I.S. SUPPLY FLP ENCLOSURE
MAINS SUPPLY
DUMP VALVE
0.V
SOL.SUP
LOCKOUT CIRCUIT
LOCKOUT CIRCUIT
DATA IN/OUT
CLOCK
LOGIC SUPPLY
SOL SUPPLY
0V
SET
ADJ LOW
ADJ LOW
BI DIRECTIONAL OVERRIDES
BI-DIRECTIONAL OVERRIDES
SLI
ADVANCE
LOWER
SK12
SK13
SK12
SK13
V1 SUPPLY
PS SET
PS LOW
PS ADV
V4 SUPPLY
V2 SUPPLY
V3 SUPPLY
PS NOT ADV
0V RETURN
NOT USED
PL15 NOT USED
PL15 NOT USED
ADDRESS PLUG 133782 MK
PL14
PL14
VALVE PACK 107567-MK-60
VALVE PACK 107567-MK-60
PULSE GEN
TERMINATION UNIT 140787 MK-30

FIGURE 9
ELECTRICAL DIAGRAM - SYSTEM
(L.S.U. TYPE) TYPICAL

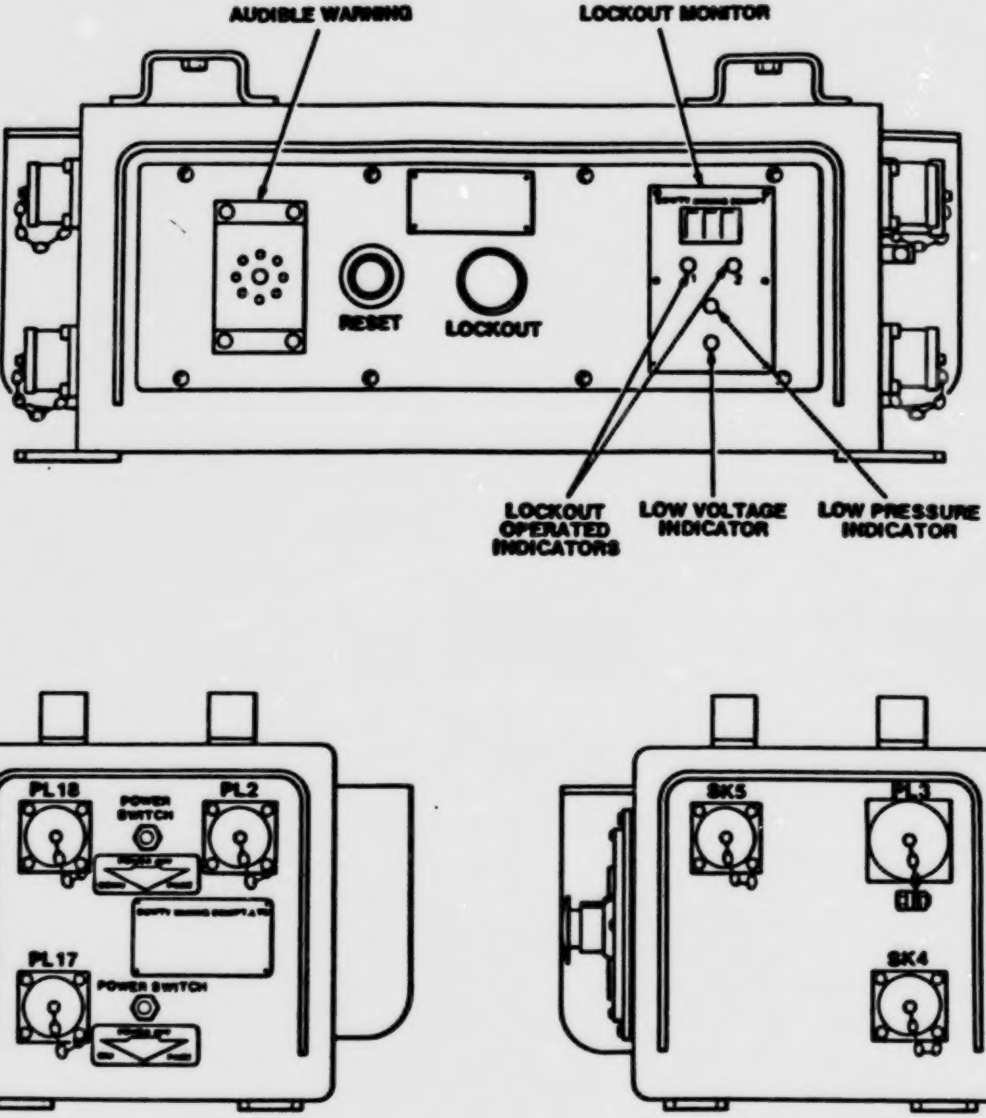

AUDIBLE WARNING
LOCKOUT MONITOR
RESET
LOCKOUT
LOCKOUT OPERATED INDICATORS
LOW VOLTAGE INDICATOR
LOW PRESSURE INDICATOR
PL18
POWER SWITCH
PL2
PL17
POWER SWITCH
SK5
PL3
SK4

FIGURE 10
SUPPLY INTERLOCK UNIT (TYPICAL)

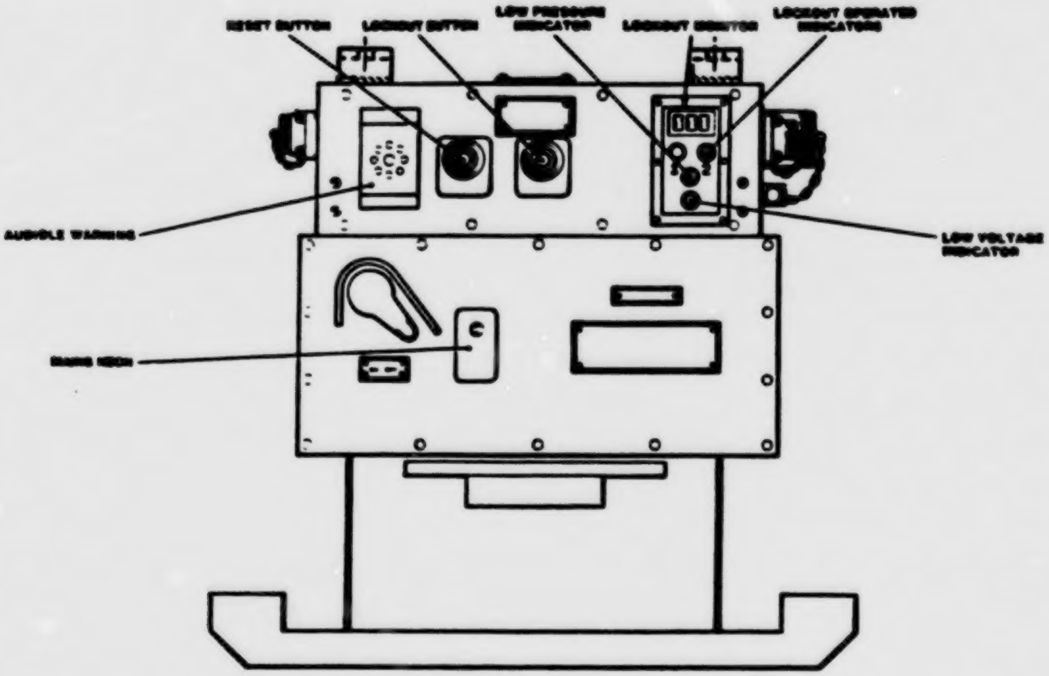

RESET BUTTON
LOCKOUT BUTTON
LOW PRESSURE INDICATOR
LOCKOUT MONITOR
LOCKOUT OPERATED INDICATORS
AUDIBLE WARNING
LOW VOLTAGE INDICATOR

FIGURE 11
LOCKOUT SUPPLY UNIT (TYPICAL)

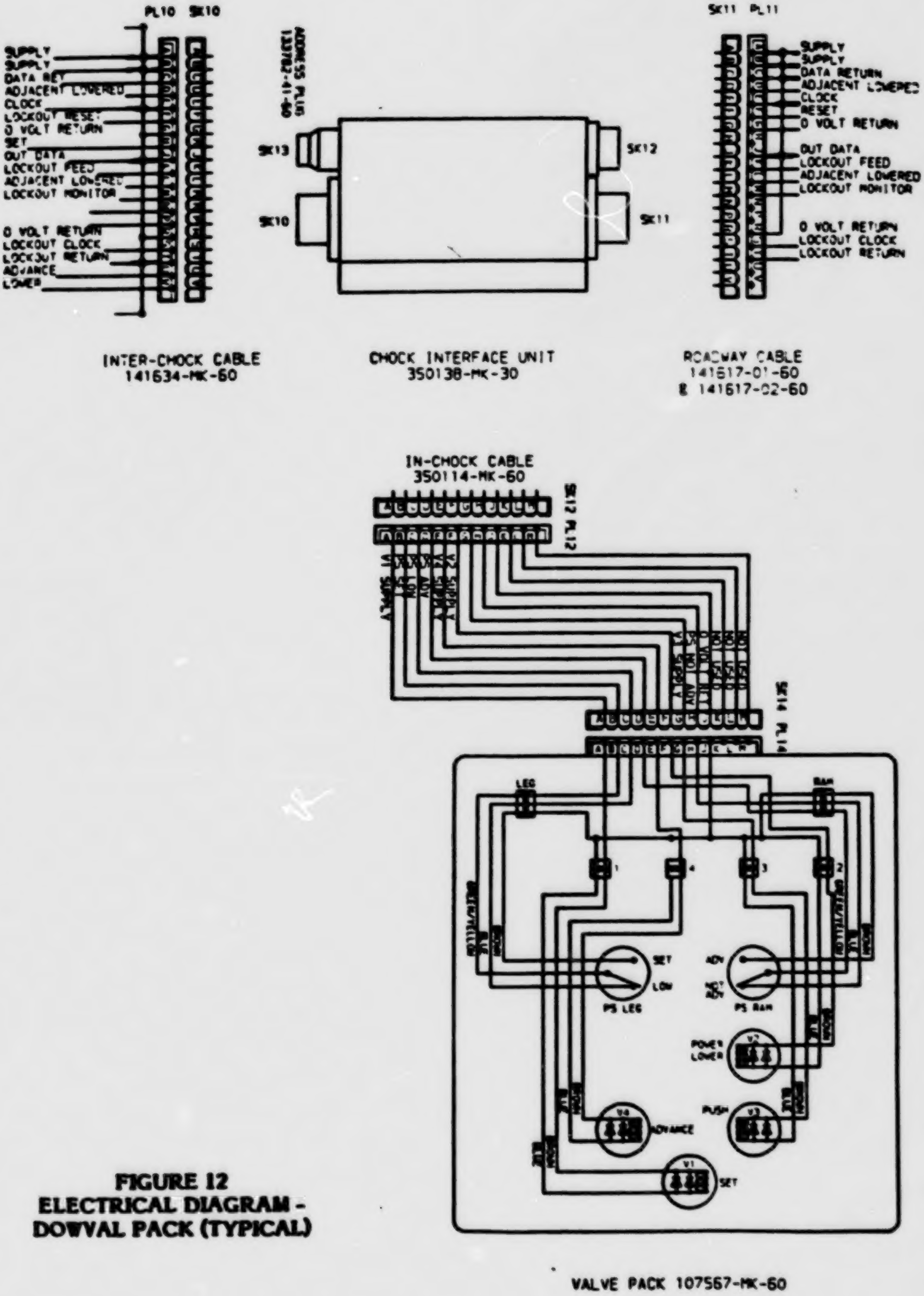

PL10
SK10
SUPPLY
SUPPLY
DATA RET
ADJACENT LOWERED
CLOCK
LOCKOUT RESET
0 VOLT RETURN
SET
OUT DATA
LOCKOUT FEED
ADJACENT LOWERED
LOCKOUT MONITOR
0 VOLT RETURN
LOCKOUT CLOCK
LOCKOUT RETURN
ADVANCE
LOWER
ADDRESS PLUG 133782-41-60
SK13
SK10
SK12
SK11
SK11
PL11
SUPPLY
SUPPLY
DATA RETURN
ADJACENT LOWERED
CLOCK
RESET
0 VOLT RETURN
OUT DATA
LOCKOUT FEED
ADJACENT LOWERED
LOCKOUT MONITOR
0 VOLT RETURN
LOCKOUT CLOCK
LOCKOUT RETURN
INTER-CHOCK CABLE
141634-MK-60
CHOCK INTERFACE UNIT
350138-MK-30
ROADWAY CABLE
141617-01-60
& 141617-02-60
IN-CHOCK CABLE
350114-MK-60
SK12 PL12
V1 SUPPLY
LOW
ADV
V2 SUPPLY
V3 SUPPLY
NOT ADV
0 VOLT RET
NOT USED
NOT USED
SK14 PL14
LEG
RAM
1
4
3
2
SET
LOW
PS LEG
ADV
NOT ADV
PS RAM
POWER LOWER
V2
PUSH
V3
V4
ADVANCE
V1
SET
GREEN/YELLOW
BLUE
BROWN
VALVE PACK 107567-MK-60

FIGURE 12
ELECTRICAL DIAGRAM -
DOWVAL PACK (TYPICAL)

GLOSSARY OF TECHNICAL TERMS FOR ELECTRO-HYDRAULIC CONTROL

Address Plug
A detachable electrical plug fitted to a C.I.U. to determine its address for control purposes. This address is established by wiring the plug to a binary code so that 8 connections can specify 254 addresses, i.e. 1 - 254.

Bank Push
A programmable facility enabling conveyor advance to be activated on a bank of supports in unison and is employed on supports at the maingate end of the face only.

Chock Control Unit (C.C.U.)
A support mounted electronic control unit based on discrete logic (non-microprocessor). These units contain all the necessary control circuitry for sequencing the supports, also for creating prime and initiate signals.

Chock Control Master Unit (C.C.M.U.)
A non-programmable face end computer used in conjunction with chock interface units for monitoring and controlling the support system.

Chock Interface Unit (C.I.U.)
A support mounted electronic control unit operated from a microcomputer such as a P.S.C.C. or C.C.M.U. As the name implies, the hardware merely serves as an interface between the operator, the face end computer and the support to be controlled.

Disable
Movement of the 'prime cancel' switch to the ✱ 'disable' position will cancel any primes resident within the control unit and permanently prevent any prime being tranferred from either of the adjacent supports.

Dump Valve
A solenoid opetated hydraulic servo unit conected into the main or pilot supply lines to the face. Under normal conditions the solenoid valve is continuously energised causing the dump valve to maintain full system pressure to the face. A pressure switch in the dump valve maintains the integrity of the face electrical supply via the 'low pressure' interlock in the LSU/SIU during this condition.
During a lockout condition, the solenoid valve is de-energised causing the dump valve to isolate the flow from the pump(s) and to dissipate any pressure remaining in the face lines. The face electrical supply is interrupted simultaneously.

Flameproof (F.L.P.)
An enclosure for electrical apparatus so designed that an internal explosion of flammable gas will not ignite flammable gas outside.

Headway
The pre-set safety distance between support system functions e.g. support advance and conveyor advance, or support functions and the power loader. For example: The headway between the sprag retract function and the leading drum of the power loader is usually set to a minimum distance of 3 supports.

In-Chock Cable Assembly
A flexible, staple fitting, multi-core cable linking a C.I.U. with the solenoid connector assembly on its related Dowval pack. This cable carries the 12v supplies used to drive the various solenoid valves and includes the status of the pressure switches.

Infra-Red Machine Position Sensor
A communication link between the machine and the roof support consisting of a transmitting unit (infra-red source) mounted on the machine, and a receiving unit attached to the front canopy of each support. The received infra-red signal is detected, amplified and returned via the C.I.U. to the face end controller which then determines which support is nearest to the machine. The support number and direction of machine travel is subsequently displayed on the front panel of the face end controller.

Initiate (To commence movement)
Initiation of supports is achieved by the operation of a control push button causing the primed unit within range to energise the appropriate solenoid valve(s).

Interchock Cable Assembly
A flexible, staple fitting, multi-core cable serially linking all C.I.U.'s throughout the face. This cable carries the lockout, face supplies, communications and data lines.

Interlock
A controlling or governing relationship between systems or events. For example: The supports and the power loader are interlocked in a number of operational modes. One such interlock will cause the power loader to stop immediately if its path is obstructed by an extended sprag.

Intrinsically Safe (I.S.)
A term used to describe a low powered electrical system which has been declared safe by the relevant Certifying Authority for use in a potentially explosive atmosphere.

Lockout (System disable)
The lockout button (emergency stop) when operated will halt all support movement by simultaneously interrupting the chock control electrical supply and the hydraulic supply to the face. As its name implies, the system will be permanently disabled or locked out until the operated button has been manually unlatched and the system reset at the supply unit.

Lockout Supply Unit (L.S.U.)
This unit provides the intrinsically safe (I.S.) d.c. supplies for powering the C.C.M.U./P.S.C.C., the support system, the lockout system and the dump valve. It also houses all the lockout system circuitry. The unit consists of a flameproof (F.L.P.) enclosure housing the mains transformer and rectifier assembly for generation of two 12v d.c. supplies. The lockout system circuitry, intrinsically safe (I.S.), is housed in a non-F.L.P. enclosure.

Manual (Electrical) Override
A means of controlling a support from toggle switches on its neighbouring supports. These switches apply 12v D.C. directly to the solenoid coil regardless of the address and therefore can override electrical hardware failure.

Odometer
A distance measuring device used to determine the movement of a power loader consisting of a pair of switches operated by a rotating cam driven from the power loader haulage system. The order in which the switches operate gives the direction of travel, and the interval between switch closures provides the distance travelled.

Prime (To electronically prepare a support for operation of remote functions) [Refer to Initiate]
A primed support indicates its condition by sounding its audible alarm and by flashing its red warning L.E.D.
The 'primed' condition can be established in two ways:-

a) Manual prime; where the operator enters the condition by operating the prime switch and a control push button simultaneously.
b) Adjacent prime; where the unit is primed automatically from a function when the adjacent support completes that function.

Powered Support Control Centre (P.S.C.C.)
An alternative face end controller to the C.C.M.U. providing programmable control and improved diagnostics.

Remote Manual Control (Support Set)
A programmable facility enabling lowered supports to be reset directly from the P.S.C.C.

Supply Interlock Unit
This unit performs the same function as the L.S.U. except that its incoming supply is already at 12v d.c. i.e. it does not require a mains rectifier assembly and therefore needs no F.L.P. enclosure. This unit is used principally in the U.S.A.

Software
The set of instructions stored within the face end computer (P.S.C.C./C.C.M.U.) controlling the way in which the hardware (C.I.U.'s) operates. The instructions are stored within devices termed E.P.R.O.M.S. (erasable, programmable, read only memories). EPROMS which have been programmed are sometimes referred to as 'firmware'.

Solenoid Manifold
The solenoid valves and pressure switches are mounted on this manifold which in turn is attached to the Dowval pack to form the true interface between the electronic and hydraulic control systems. When activated, the solenoid valves transmit pilot signals within the Dowval pack to effect the various functions which are then monitored by the pressure switches.

Termination Plug
This plug is used in place of the outgoing interchock coupler on the last C.I.U. in the system. The plug contains an oscillator circuit for feeding the lockout system circuitry at the L.S.U./S.I.U. It also provides a return path back to the C.C.M.U./P.S.C.C. for transmitted data. This return path allows the C.C.M.U./P.S.C.C. to check that the data returned is identical to that transmitted i.e. that data corruption has not occurred.

Timed Positive Set
A means of setting a support whereby the unit continues to set via leg circuit non-return valves for a pre-determined time after achieving a minimum safe (pre-set) pressure. The pressure in the legs at the end of the charge period should therefore be equal to the maximum pump pressure available during the charge period.

Note: The P.S.C.C. can provide a range of setting times.

Elektrohydraulische Ausbausteuerung Panzermatic®-E
Panzermatic®-E Electro-Hydraulic Controls For Roof Supports

Westfalia/Siemens

Elektrohydraulische Ausbausteuerung Panzermatic®-E

Die ständig zunehmende Automatisierung der Kohlen- und Mineralgewinnung sowie der verstärkte Wunsch nach einer weiteren Humanisierung der Arbeitsplätze waren für die beiden Unternehmen Siemens AG und Westfalia Lünen Anlaß, gemeinsam das moderne Ausbausteuerungssystem Panzermatic®-E zu schaffen.

Durch konsequente Anwendung modernster Technologie (Mikrocomputertechnik) und zeitgemäßer Hydraulik ist es gelungen, ein Steuerungssystem zu erstellen, das sowohl heute als auch in der Zukunft geeignet ist, die wachsenden Aufgaben zu erfüllen.

Eine Mikrocomputersteuerung in jedem Ausbau sorgt dafür, daß der Funktionsablauf optimal ausgeführt wird. Sensoren für Drücke und Wege bringen die nötigen Informationen an den Steuerrechner, der mit diesen Daten die notwendigen Befehle für die Hydraulik-Komponenten errechnet und zur Verfügung stellt. Robuste Elektromagnetventile, die direkt mit dem Hochdruck der hydraulischen Strebversorgung beaufschlagt werden können, bringen die Funktionen am Ausbau zur Ausführung.

Durch die modulare Ausführung des Systems entfallen alle komplizierten hydraulischen Steuerelemente. Somit werden Steuerungsabläufe vom Ausbaurechner bestimmt, während die Hydraulik als Stellglied arbeitet. Dadurch ist das System extrem wartungsarm, alle Justierarbeiten entfallen.

Steckbare Verbindungen zwischen den einzelnen Komponenten und den fertig konfektionierten Leitungen erlauben selbst ungeschultem Personal unter ungünstigen Strebverhältnissen schnell für einen Austausch der Elemente zu sorgen.

Die Informations- und Befehlsübertragung auf elektrischem Wege arbeitet mit Leitungsüberwachung, womit komplizierte Überkreuzsteuerungen an den Strebenden vermieden werden.

Leicht zugängliche und übersichtliche Drucktasten am Steuergerät erlauben selbst unter schwierigen Betriebsbedingungen eine einwandfreie Betätigung. Durch logische Verknüpfungen wird eine Fehlbedienung ausgeschlossen.

Die Vorteile dieses Steuerungskonzepts liegen in der Realisierung kurzer Umsetzzeiten und dem sicheren Setzen der Stempel mit genau definiertem Setzdruck, womit eine optimale Hangendbeherrschung möglich ist.

Als weitere Vorteile sind zu nennen: Überwachung und Meldung von Betriebszuständen und Funktionen, einheitlicher Aufbau der Steuerung für alle Gewinnungssysteme und Betriebsbedingungen und – last not least – Kosteneinsparungen. Ein Umbau der Steuerungen bei Folgeeinsätzen entfällt.

Durch die hierarchisch dezentrale Struktur der Steuerung, bestehend aus Einzelsteuergeräten und Hydraulikventilblöcken in den Schilden und einem Zentralsteuergerät, das an einem übersichtlichen Platz, z.B. in der Strecke, angeordnet werden kann, sind folgende Steuerungsmöglichkeiten realisiert worden:

Rein hydraulisch ausbaueigen, vorgesehen für Reparaturbetrieb oder untergeordnete Einzelfunktionen	– Steuerung aller vorhandenen Ausbaufunktionen mit Totmannschaltung
Elektronisch vom Einzelsteuergerät ohne Zentralsteuergerät	– Einzelfunktionssteuerung bidirektional (bis zu sieben Funktionen elektronisch)

Panzermatic®-E Electro-Hydraulic Controls For Roof Supports

The rapid evolution of flexible mining techniques and the need to minimize the operator exposure to mining hazards led to the development of the modern electro-hydraulic control system Panzermatic®-E for roof supports by the joint efforts of Siemens AG and Westfalia Lünen.

The combined application of the most up to date microcomputer technology and of the most reliable hydraulic valve system ensures that this new control system will satisfy not only the requirements of today but those of tomorrow.

Each support is equipped with a microprocessor. Sensors monitor pressures and motions, transmitting this information to the computer which, in turn, determines the requisite commands to the hydraulic system. Rugged solenoid valves, which are directly connected to the high-pressure supply system, trigger the support functions, by admitting pilot fluid to the valves.

The functions are controlled by the computer, and the valves serve merely as coupling elements to the cylinders. As a result, the maintenance content is very low, and the need for adjustments is eliminated.

The system is of a simple modular design. All cables are protected by strong conduit hoses which are equipped with the same quick-action plug-type fittings as the hydraulic hoses. No special skill is required, therefore, to replace defective components.

Complex face-end, criss-cross hosing is eliminated because both information and commands are transmitted electronically.

The push buttons provided on the microprocessor units are highly accessible and easy to operate; the logic system also prevents operator errors.

Apart from these advantages improved roof control may be expected due to the positive set feature and the rapid support cycle. At the same time, a display of the face situation is available at all times. The control systems become standard for all methods of mining, for either face orientation and are independent of the direction of ventilation or pitch.

The control system is functionally decentralised and consists of several superimposed levels of controls. Its components are the hydraulic valve banks, the solenoid valves and the unit control station (microprocessor) – all situated within the shield and the central control unit, or master station which is located in the belt entry.

The optimum control system consists of a master unit combined with the individual microprocessors. It is also possible, however, to operate in certain modes without a master unit. Finally, direct hydraulic control is always available for trouble-shooting or as a manual override.

The various levels of operations are as follows:

Direct hydraulic control for manual override of individual functions or for trouble-shooting and repair	– Individual control of each function, with the safety feature of "dead man's handle".
Electronic unit control (without master unit)	– bi-directional control of up to seven individual functions; bi-directional sequential

	– Einzelfolgesteuerung vom gesetzten Nachbarausbau aus (automatischer Ablauf einer vorbestimmten Folge)
Elektronisch vom Einzelsteuergerät mit Zentralsteuergerät	– Einzelfunktionssteuerung – Einzelfolgesteuerung – Gruppenfolgesteuerung mit gleitender Gruppe (floating group) durch Parametrierung von strebabhängigen Größen (Gruppengröße, Raubzeit)

Alle Komponenten sind eigensicher ausgeführt. Die Betriebsspannung beträgt 12 V Gleichspannung.

Steuerungsaufbau

Die Steuerung besteht aus folgenden Hauptbauteilen:
1) Hydraulische Arbeitsventile
2) Elektromagnetventile
3) Elektronisches Einzelsteuergerät mit Mikroprozessor
4) Zentralsteuergerät
   (nur für Gruppenfolgesteuerung erforderlich).

1) Die hydraulischen Arbeitsventile wurden von der bewährten Kipphebelsteuerung übernommen.
2) Die Elektromagnetventile sind als Stellgliedeinheit auf einer hydraulischen Verteilerplatte zusammengefügt. Diese Stellgliedeinheit wandelt die elektrischen Impulse in hydraulische Steuerimpulse um, die die hydraulischen

Electronic control with the unit control station and combined central control unit	– bi-di control of individual functions; – bi-di sequential control; – bi-di batch control with a floating group, and – bi-di bankpush – both programmable in respect of face-dependent parameters (size of batch, time for lowering props, etc.)

All the components are intrinsically safe and operate at 12 V D.C.

Description Of Control System

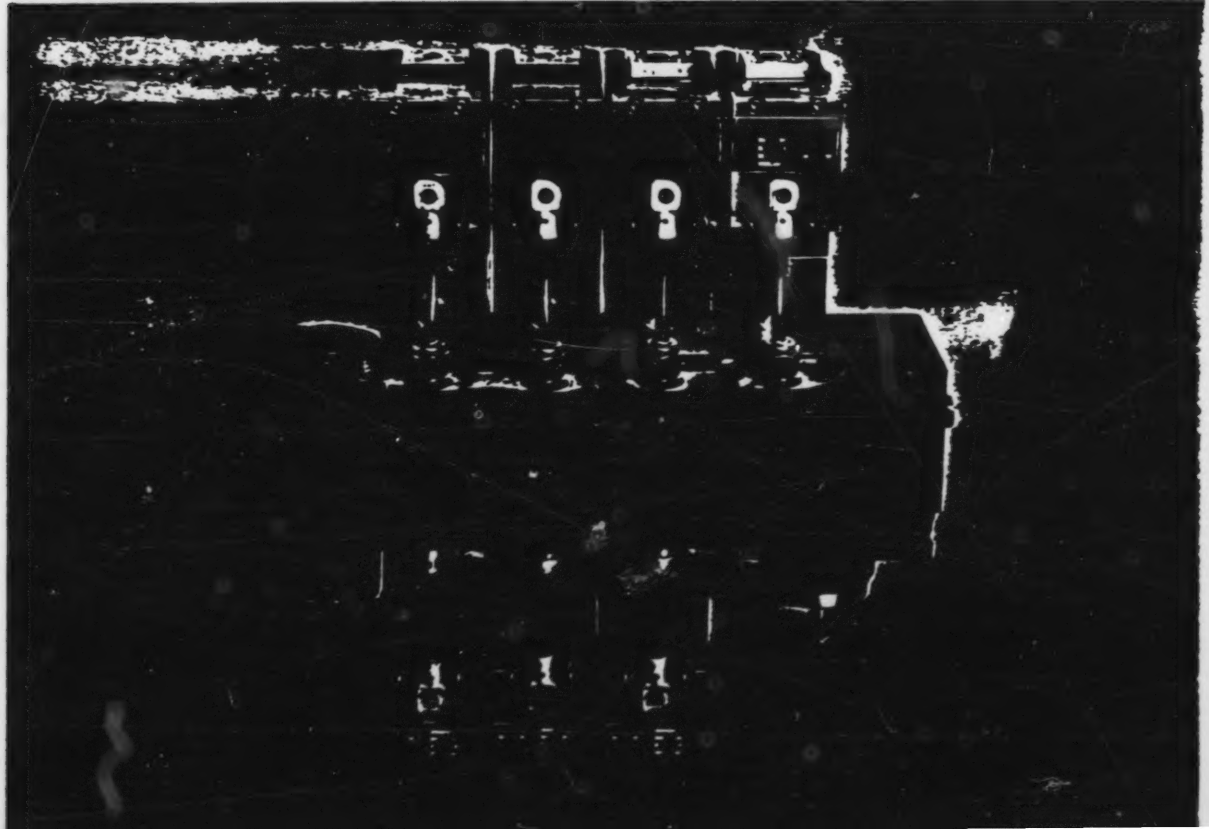
The control system consists of four major components:
1) The hydraulic directional valves
2) The solenoid valves
3) The electronic unit control station with the microprocessor
4) The central control station or master unit – this is only required for batch control

re – 1) The pilot-operated hydraulic directional valves are identical with the ones used in the piano-key selector system. They are mature and reliable.

re – 2) The solenoid valves are transmission elements and are mounted, as a unit on a hydraulic manifold. They convert the electrical impulses into hydraulic signals

Abb. 1: Elektrohydraulische Stellgliedeinheit mit sieben Elektromagnetventilen

Fig. 1: The electro-hydraulic transmission unit with seven solenoid valves



Arbeitsventile betätigen. Die Elektromagneten der einzelnen Ventile benötigen 56 mA bei 12 V, um eine Funktion auszulösen und aufrechtzuerhalten. Alle Elektromagnetventile besitzen eine Nothandbetätigung am Elektromagneten.

Diese elektrohydraulische Wandlereinheit besitzt auf der elektrischen Seite einen Schlauchkabelanschluß und auf der hydraulischen Seite einen Multischlauchanschluß. Diese Einheit kann an günstiger Stelle im Ausbau befestigt werden (modulare Bauweise).

3) Elektronisches Einzelsteuergerät Panzermatic®-E
In diesem kompakten Gerät befindet sich die Steuerlogik und das Bedienfeld. Jedes Gerät besitzt einen eigenen Prozessor, Typ Intel 8748. Mit ihm werden alle Funktionsabläufe des Ausbaus unabhängig von der Zentrale überwacht. Die meisten Schaltkreise sind in C-MOS-Technik ausgeführt, die die zur Zeit geringste elektrische Leistungsaufnahme garantiert.

4) Zentralsteuergerät
Die Aufgabe des Zentralsteuergerätes ist es, Bewegungsabläufe des Ausbaus, die durch die Einzelsteuergeräte der Panzermatic®-E-Ausbausteuerung initiiert wurden, zu koordinieren und zu überwachen. Ebenso lassen sich bestimmte prozeßspezifische Parameter, wie z.B. die Raubzeit, Größe der gleitenden Gruppe, Anzahl der Strebendschilde und Synchronisationspunkt des Anzeigers für das Gewinnungsgerät einstellen.

Der Strebzustand wird durch ein Leuchtdiodenfeld und zusätzlich durch Ziffernanzeigen dargestellt. Die Position des Gewinnungsgerätes wird einmal durch eine Leuchtdiodenzeile in analoger Form und zum anderen durch zwei dreistellige Ziffernanzeigen in Metern und in Ausbau-

and provide the pilot fluid for the operation of the hydraulic valves.

The solenoid valves require 56 mA at 12 V for initiating and maintaining a function. Each one of the valves is equipped with the facility for manual operation at the electro-magnet.

On one side of this electro-hydraulic conversion unit a hose-protected cable is plugged-in, and on the opposite side a coaxial multiduct hydraulic hose is inserted. The unit is attached to a convenient location – such as a recess in the canopy – on the support unit.

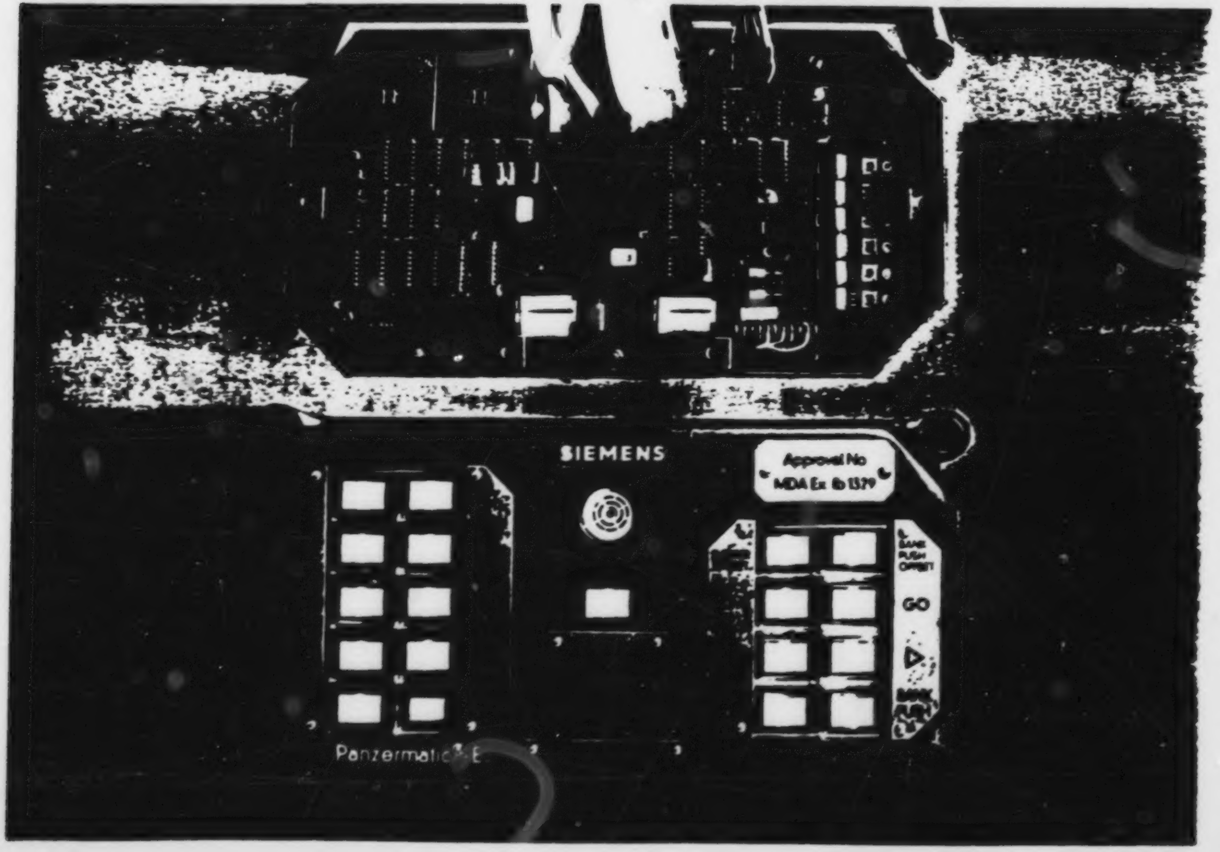
re – 3) The electronic unit control: Panzermatic®-E. This compact unit combines the control logic and the push-button station. Each unit is equipped with an INTEL 8748 microprocessor. This controls all the functions of the support, detached from the master unit. Most of the circuits are executed in the C-MOS technique which guarantees the lowest energy input.

re – 4) The master control unit: The function of the master control unit is to coordinate and to check the support cycle or cycles which have been initiated at one of the unit control stations of the Panzermatic®-E control system. At the same time, the microprocessors are programmed from the master unit with regard to a number of parameters, such as time for lowering the props, size of batch, synchronization of the position indicator for the mining machine, etc.

The display of the position of the face is effected by light-emitting diodes and by numerical indicators. The position of the mining machine is shown in two ways: by means of a line of diodes, and also by two three-digit numerical counters, which show the

Abb. 2: Gehäuse eines Panzermatic®-E-Einzelsteuergerätes (geöffnetes Gehäuse und Frontansicht)

Fig. 2: The Panzermatic®-E unit control housing (Front view with and without the cover)



einheiten digital angezeigt. Drei Leuchtdiodenzeilen geben Auskunft darüber, welcher Ausbau sich in der Stellung „Förderer gerückt" und „Ausbau nachgezogen" befindet und wo z. B. eine Störung aufgetreten ist. Eine unter den Leuchtdiodenzeilen angeordnete elektronische Lupe sorgt dafür, daß die Übersichtsinformationen durch die LED-Zeilen in Matrixform genau aufgeschlüsselt werden. Ein Schlüsselschalter verhindert, daß unautorisiertes Personal Manipulationen, z. B. der Prozeßparameter, vornehmen kann.

Das Zentralsteuergerät bietet die Möglichkeit, über Tage den Prozeßrechner Siemens R 30 anzuschließen und die Strebdaten dort zu bearbeiten bzw. darzustellen. Eine äußerst leistungsfähige Software sorgt dafür, daß alle Steuerbefehle für den Ausbau, die im Streb gegeben werden, in übersichtlicher Form protokolliert werden und eine Schichtstatistik erstellt wird. Ebenso ist eine Fernparametrierung von über Tage möglich.

Merkmale

- Mit der Panzermatic®-E-Steuerung können insgesamt bis zu 240 Schilde gesteuert werden.
- Das Ausbauschreiten kann bei jedem Schild beginnen. Dazu wird der Schild durch Drücken der „Prime-Taste" als der erste bestimmt, der sich innerhalb einer gleitenden Gruppe bewegen soll. Damit erhält der Bedienungsmann eine Bedienfreigabe innerhalb einer gleitenden Bediengruppe, von wo er die Ausbauschilde „fernsteuern" kann. Durch das Mitwandern der gleitenden Bediengruppe ist der gerade schreitende Ausbau immer im Gesichtsfeld

position of the mining machine in meters and in respect to the number of the support in whose vicinity it is operating. Three diodes indicate which support has been advanced, opposite which shield the conveyor has been pushed over and where any problem has arisen. An electronic magnifier arranged under the light-emitting diode lines improves the resolution of the display.

The master control unit is locked by a key to prevent unauthorized interference.

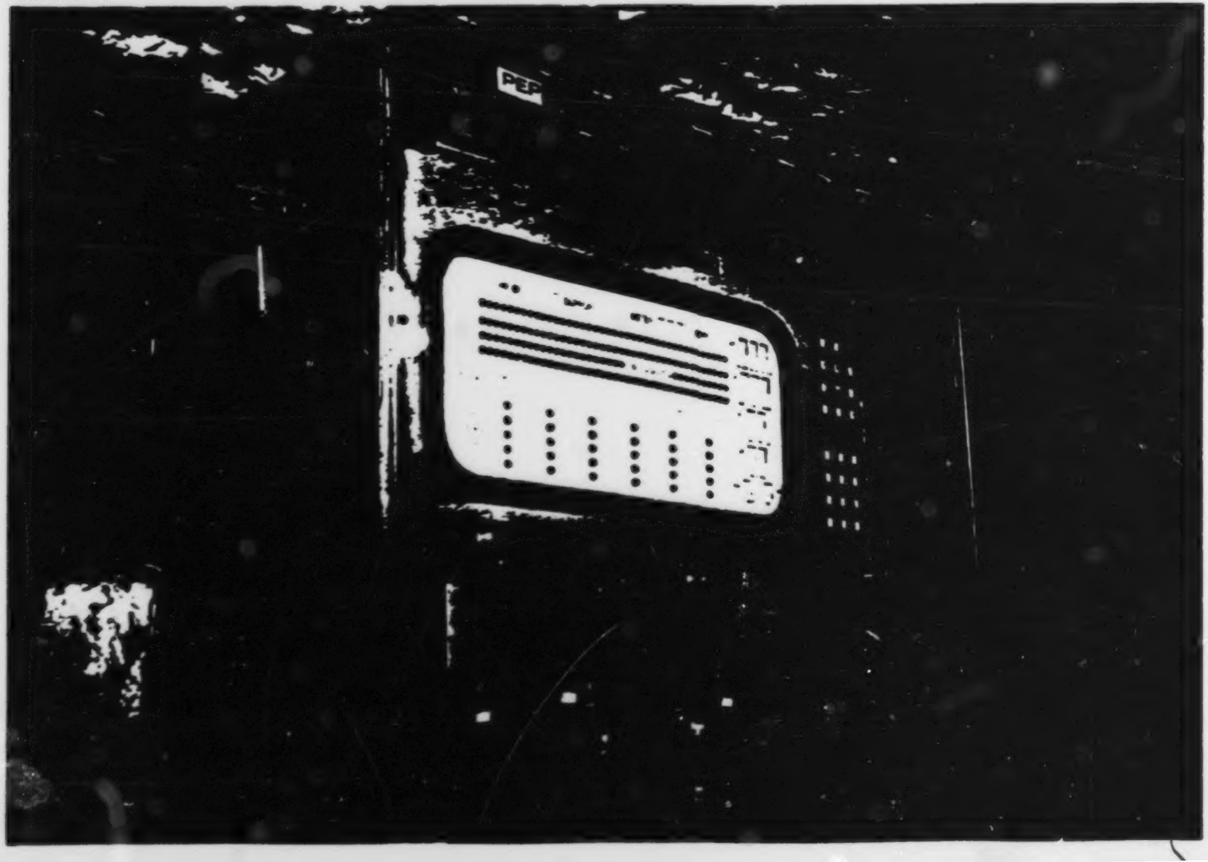
If desired, the master control unit may be coupled to a Siemens R 30 surface monitoring unit for processing or displaying the face data. Suitable software exists which permits the recording of all control commands issued on the face and the printout of a statistical tabulation for the shift. Conversely, the support control system may be reprogrammed from the surface monitor.

Other Features Are As Follows

- A total number of 240 shields may be controlled by the system.
- The support advancement cycle may start at any shield, by depressing the "prime button" of the shield in question. The shield so primed will then be first advanced within a floating control group. Its move may be initiated from any other shield – within the floating control group – remotely. Since the floating control group follows the shield advancement, the support being moved up is within sight of the shield operator.

Abb. 3: Zentralsteuergerät auf dem Bergwerk Quarto No. 4, Ohio, USA

Fig. 3: The central control unit at the Quarto No. 4 mine, Ohio, U.S.A.



des Bedienungsmannes.

- Die Schilde können vor oder hinter dem Gewinnungsgerät vom staubfreien Bereich aus innerhalb der Bediengruppe in Gruppenfolge gesteuert werden.
  Gleichzeitig ist an jedem Schild außerhalb der Bediengruppe Einzelfunktions- bzw. Einzelablaufsteuerung möglich.
- An jedem Steuergerät ist eine „Automatik-Stop"-Taste vorhanden, mit der die automatischen Abläufe jederzeit gestoppt werden können.
  Diese Taste ist mechanisch verriegelt und muß erst entriegelt werden, bevor ein automatischer Ablauf wieder gestartet werden kann. Die Funktion der Taste kann von keiner anderen Funktion überlagert werden.
- Alle elektrischen Verbindungsleitungen sind durch Schläuche geschützt, die bergbauübliche Steckverbinder besitzen.

Die Panzermatic®-E-Westfalia/Siemens-Steuerungen haben durch mehrjährige Piloteinsätze im In- und Ausland ihre Zuverlässigkeit nachgewiesen.

Panzermatic®-E-Ausbausteuerungssystem

Wie bereits dargelegt, lassen sich bis zu 240 Ausbaueinheiten von einem System steuern.

Die einzelnen Steuergeräte sind über ein Bussystem untereinander und durch ein weiteres Bussystem mit dem Zentralsteuergerät verbunden.

Bei der Bedienung wird ein Funktionstelegramm zum angewählten Schild über den bidirektionalen Datenbus gesendet.

- The shields may be advanced remotely – within the floating control group – on either side of the shearer, from a dustfree position.
  At the same time, it is possible to execute individual functions or sequential control in a bi-di mode, outside the floating control group.
- Each unit control station is equipped with an "Automatic-Stop" button. By depressing this all automatic functions are suspended immediately.
  This button is mechanically latched, and must, therefore, be unlocked before any automatic control function can be resumed. No other function can override the effect of this button.
- All electrical cables are sheathed in hydraulic hoses which – in turn – are equipped with Stecko fittings.

The Westfalia/Siemens Panzermatic®-E controls matured over several years of pilot operations to their present state of reliability.

Panzermatic®-E Roof Support Control System

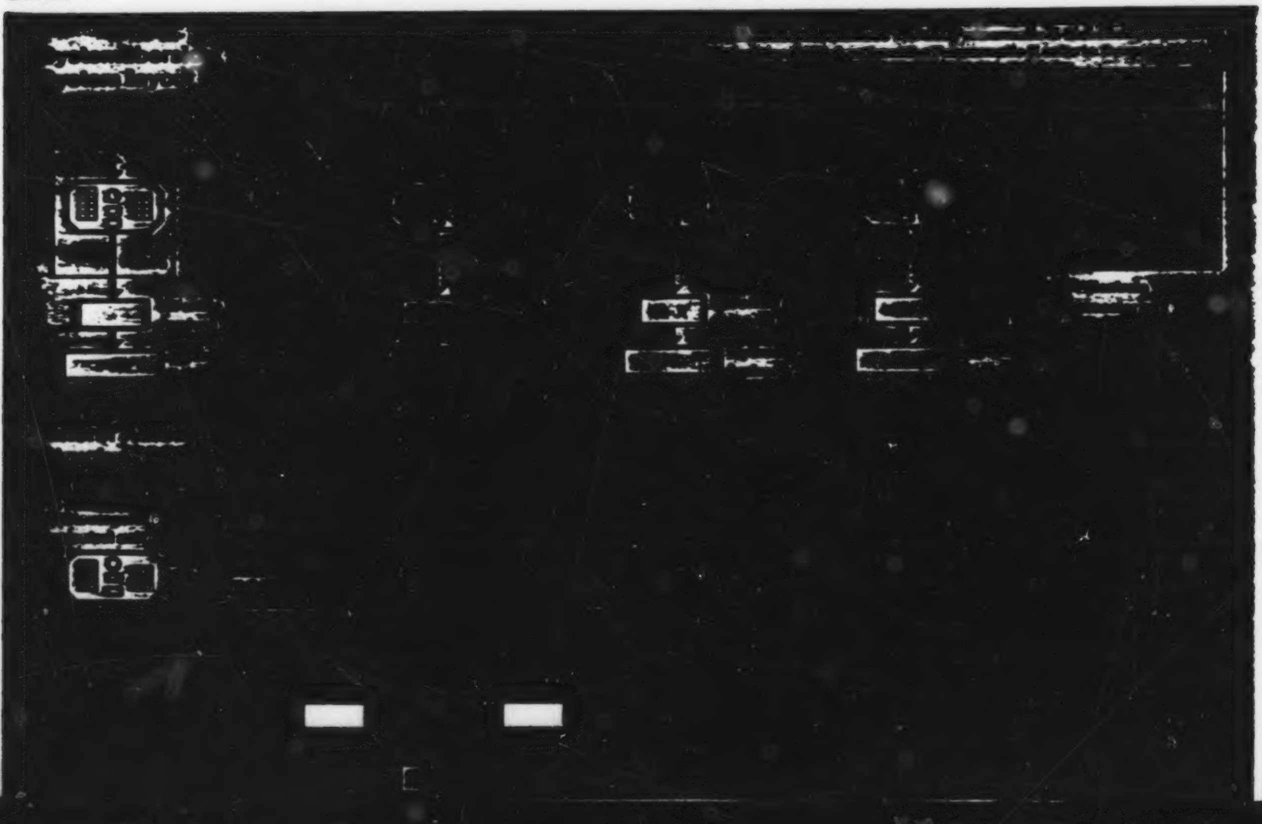
As mentioned before up to 240 support units may be controlled by one system.

The individual microprocessors are interconnected by databus and a similar connection links them with the master unit.

If a function is selected for an adjacent support, the signal is sent to it via the bi-di data-bus. The signal is received,

Abb. 4: Systemübersicht / Innerer Aufbau einer Panzermatic®-E-Einheit

Fig. 4: System layout/Block diagram of a Panzermatic®-E unit



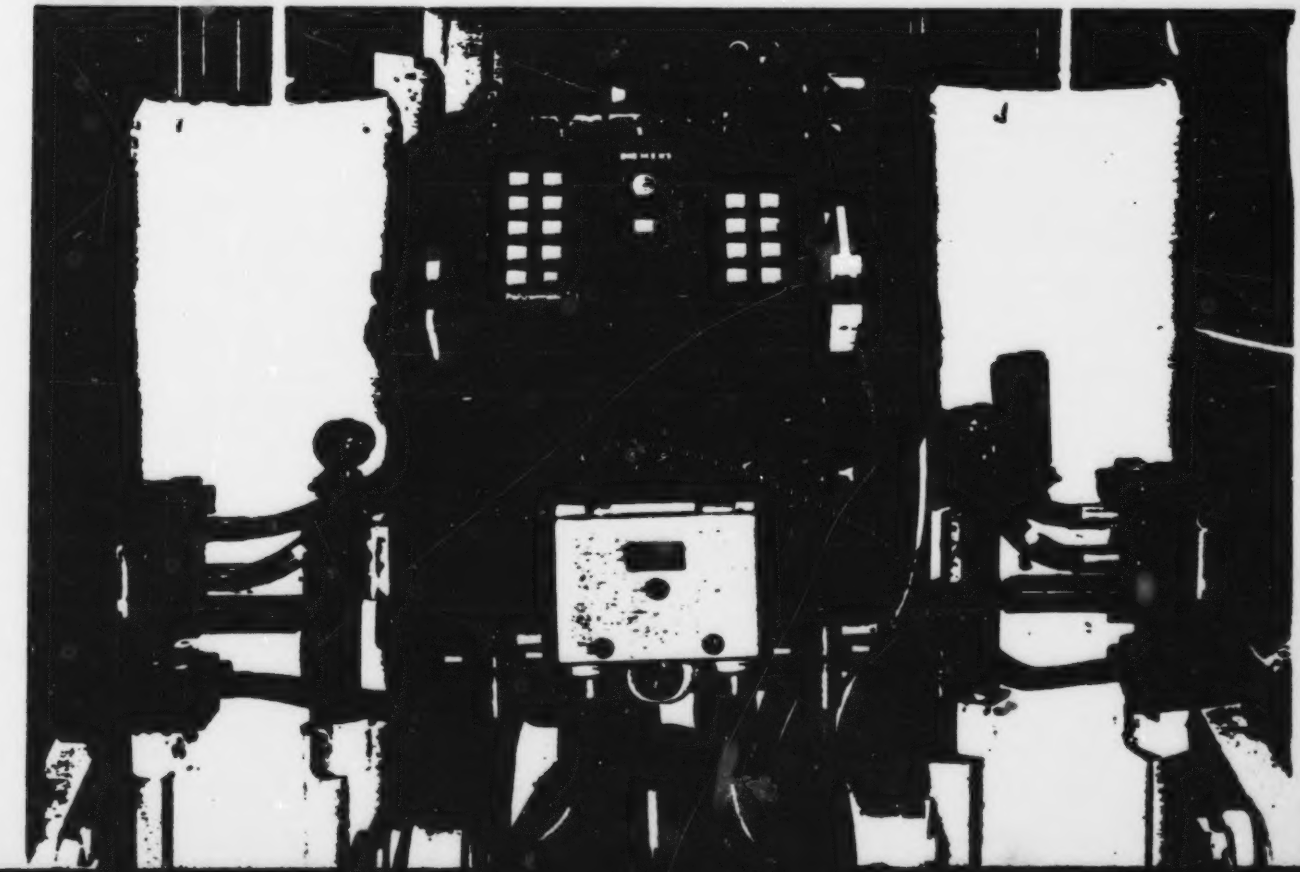
Das Einzelsteuergerät empfängt das Telegramm und überprüft seine Richtigkeit. Wenn das Telegramm in Ordnung ist, wird der Befehl ausgeführt. Tritt eine Übertragungsstörung auf, erfolgt eine Fehlermeldung. Wird eine Gruppenfolgesteuerung ausgelöst, so wird ein Telegramm an das Zentralsteuergerät über den Zentraldatenbus gesendet. Im Zentralsteuergerät wird anhand des aktuellen Strebzustandes geprüft, ob die Gruppenfolgesteuerung freigegeben werden kann. Trifft das zu, wird die Freigabe erteilt und die Gruppenfolge gestartet.

Bild 4 zeigt die innere Blockstruktur eines Steuergerätes. Rot eingezeichnet ist der Prozessor des Typs Intel 8748, in grüner Darstellung die Elemente, die für die Datenübertragung verantwortlich sind. Durch die serielle Telegrammübermittlung kommt man mit einem Minimum an Übertragungsleitungen aus. Die gelb gezeichneten Teile sind die Eingabeschnittstellen für die Druck- und Wegsensoren und die Bedienungstastatur. Die Hydraulikkomponenten sind blau dargestellt.

compared and, if found to be correct, executed by the unit control. Any problem in the transmission is displayed. If batch control is selected, the signal is sent to the maste unit via the data-bus. The master unit contains the information regarding the actual position on the face and compares this with the signal, to see whether the batch is free to be advanced or not. If it is, the cycle is initiated. Fig. 4 shows the block diagram of an electro-hydraulic contro unit. The heart of the unit is the INTEL 8748 microprocesso shown in red. The green blocks represent the data communication elements. The transmission relies on a small number of conductors only because the signals are serialised. The data input units for the pressure and motion sensors and the push buttons are shown in yellow. The hydraulic components are colored blue.

Abb. 5: Panzermatic®-E mit Doppelstromversorgungseinheit im Westfalia-Ausbauschild BS 2.1 der Ausführung Coal & Allied, Liddell Colliery, Australien

Fig. 5: Panzermatic®-E control with a dual power supply on the Westfalia BS 2.1 shield for Coal & Allied, Liddell Colliery, Australia



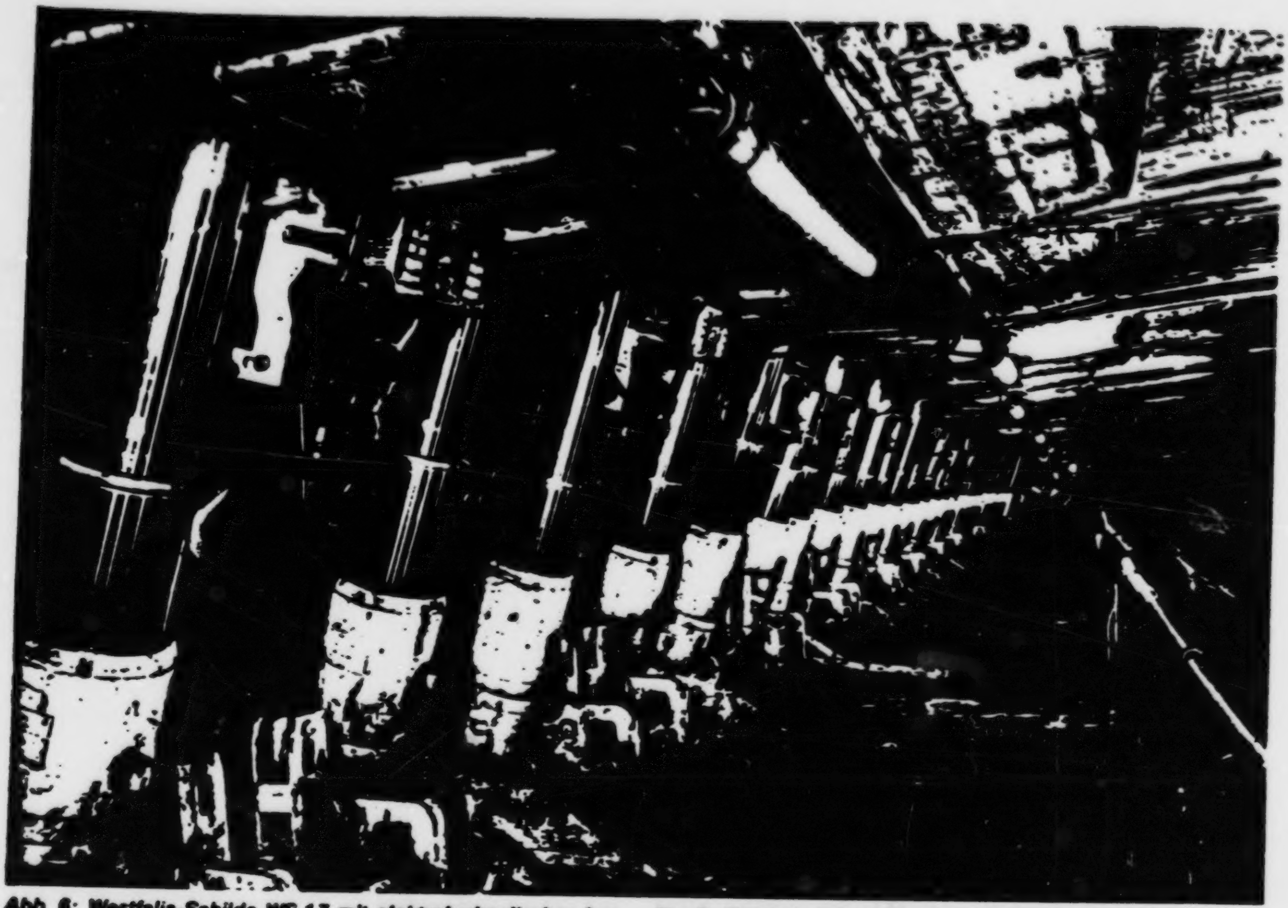


Abb. 6: Westfalia-Schilde WS 1.7 mit elektrohydraulischer Ausbausteuerung Panzermatic®-E auf Quarto No. 4, USA (Walzenschrämladerbetrieb)

Fig. 6: Westfalia WS 1.7 shields with Panzermatic®-E control on the shearer face of the Quarto No. 4 mine, U.S.A.

Eickhoff-Ausbausteuerung Typ iSW02e

Eickhoff Roof Support Control System, Type iSW02e

Gebr. Eickhoff
Maschinenfabrik u. Eisengießerei mbH
Postfach 100 629, Hunscheidtstraße 176
4630 Bochum 1
Telefon-Sammel-Nr (02 34) 77 71-1
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Telegramme Eickhoffwerk

Die Fortschritte in der Steuertechnik für den Schildausbau und bei der Übertragungstechnik vom Walzenlader zur Strecke ermöglichen es, den Ausbau in Abhängigkeit von der Position des Walzenladers zu steuern.

Eickhoff hat eine entsprechende automatische Steuereinrichtung entwickelt, die aus der zentralen Steuereinheit, einer Steuereinheit je Ausbau, dem Übertragungssystem und den nachgeschalteten Magnetventilen besteht.

Zentrale Steuereinheit

Vier aneinandergeflanschte Gehäuse – Baugröße eUN10 – bilden die zentrale Steuereinheit, in die die Stromversorgungsbausteine für die Eigenversorgung der Steuerung und für die Versorgung der Magnetventile eingebaut sind; außerdem Baugruppenträger mit Sende-, Empfangs-, Anzeige- und Eingabebaugruppen, sowie ein µ-Prozessor.

Durch Sichtscheiben in den Deckeln können Standort der Maschine, Fahrtrichtung und Stellung des Grenzwertschalters abgelesen werden.

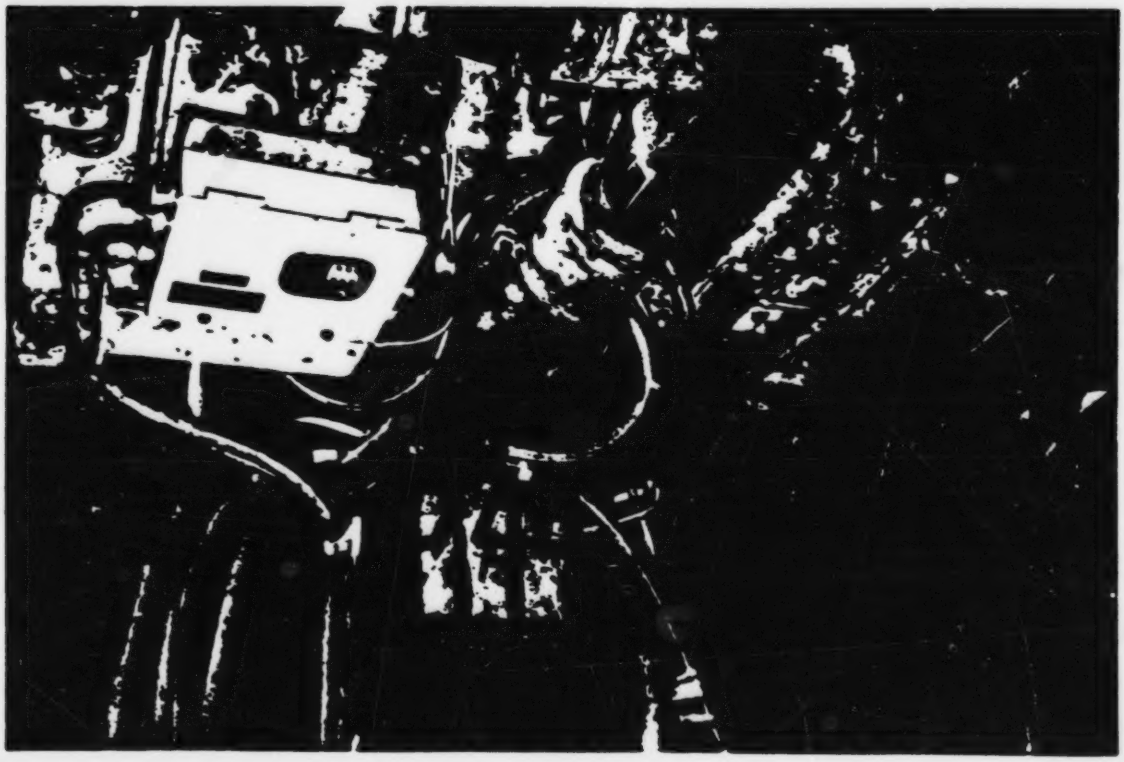
The progress achieved in the control of shield-type roof supports and in the transmission from the shearer loader to the roadway enables the control of the roof supports dependent on the position of the shearer loader.

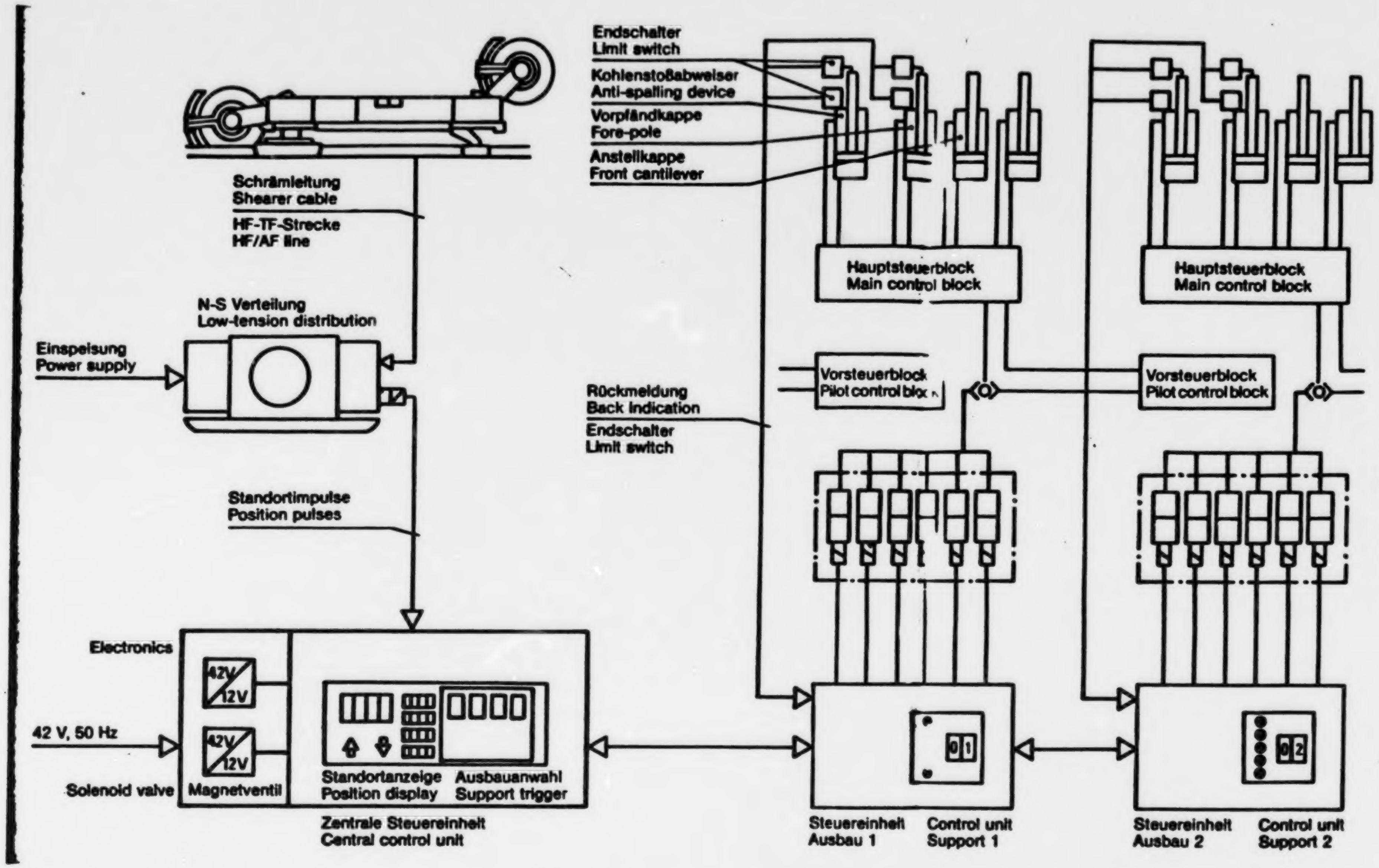
Eickhoff have developed an automatic control system comprising a central control unit, a control unit for each shield, the transmission system and the solenoid valves.

Central Control Unit

The central control unit consisting of four casings of the size eUN10 which are flanged together houses the power supply units for the control system and the solenoid valves as well as the racks for the transmitting, receiving, indicating and input units and a µ-processor.

Viewing windows in the covers enable the observation of the position of the shearer, the travelling direction and the position of the limit switch.




Endschalter
Limit switch
Kohlenstoßabweiser
Anti-spalling device
Vorpfändkappe
Fore-pole
Anstellkappe
Front cantilever
Schrämleitung
Shearer cable
HF-TF-Strecke
HF/AF line
Hauptsteuerblock
Main control block
Hauptsteuerblock
Main control block
N-S Verteilung
Low-tension distribution
Einspeisung
Power supply
Vorsteuerblock
Pilot control block
Vorsteuerblock
Pilot control block
Rückmeldung
Back indication
Endschalter
Limit switch
Standortimpulse
Position pulses
Electronics
42V
12V
42 V, 50 Hz
42V
12V
Solenoid valve
Magnetventil
Standortanzeige
Position display
Ausbauanwahl
Support trigger
01
02
Zentrale Steuereinheit
Central control unit
Steuereinheit
Ausbau 1
Control unit
Support 1
Steuereinheit
Ausbau 2
Control unit
Support 2

Die Funktionsanzeigen und Leuchtdioden geben darüber hinaus Informationen über die jeweils im Bereich der Maschine befindlichen Ausbaugestelle und über eventuelle Störungen.

Ausbau-Steuereinheit

Jedes Ausbaugestell hat eine Steuereinheit, in der sich neben einem Baugruppenträger mit Sende- und Empfangsbaugruppen, die Steuerlogik und der Adresschalter – an dem die zugehörige Ausbaugestellnummer eingestellt wird – befinden.

In der Sichtscheibe des Deckels ist der Einstellwert dieses Schalters mittels Leuchtdioden und der Schaltzustand der nachgeschalteten Magnetventile zu sehen.

Übertragungssystem

Die Standortimpulse vom Walzenlader werden mit einem HF-TF-System über die Energieadern der Schrämleitung zur Strecke übertragen, entkoppelt und von dort eigensicher zur zentralen Steuereinheit weitergeleitet.

Moreover, function indicators and light emitting diodes give information on the roof supports in the vicinity of the shearer and on any faults.

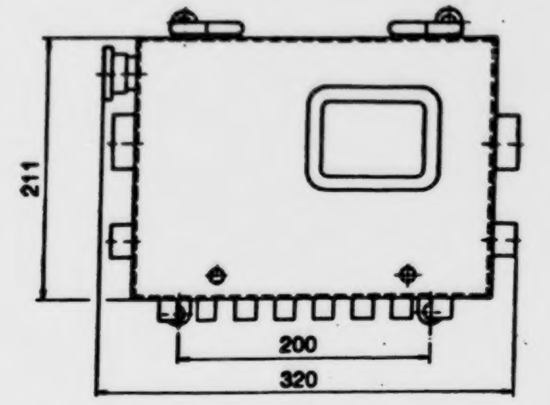
Roof Support Control Unit

Each shield is fitted with a control unit which comprises, in addition to the rack with the transmitting and receiving units, the control logic and the address switch which is set to the corresponding chock number.

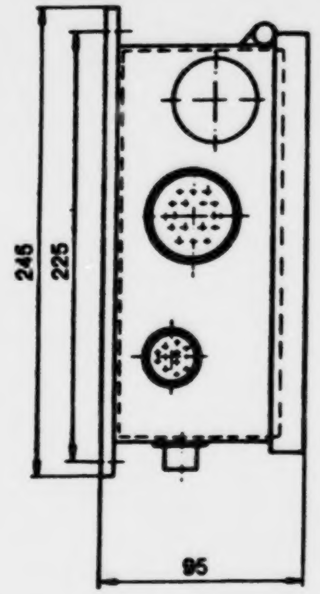
The value to which this switch is set is indicated by light emitting diodes which are visible through the viewing window of the cover, same as the state of the circuit of the solenoid valves.

Transmission System

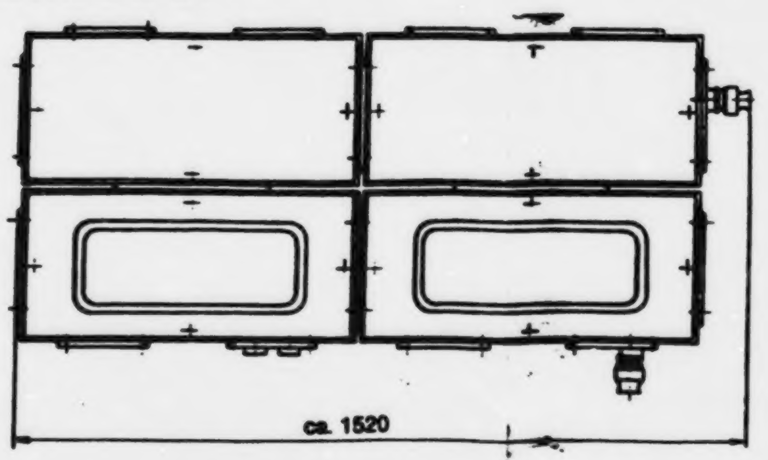
The position pulses are transmitted from the shearer loader to the roadway via the power conductors of the shearer cable by means of an HF/AF system, they are decoupled and transmitted to the central control unit where they are converted into control signals for the roof supports.

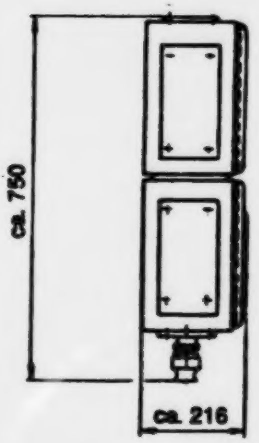


Ausbau Steuereinheit   Roof support control unit



Zentrale Steuereinheit   Central control unit




ca. 750
ca. 216

Hier erfolgt die Verarbeitung zu Steuersignalen für die Ausbaugestelle. Über eine 3-Draht-Übertragungseinrichtung wird ein 16-Bit-Datenwort seriell an alle Ausbaugestelle übertragen, in den Steuereinheiten der Ausbaugestelle geprüft und ausgewertet. Vor Ausführung der Funktion vermittelt die Steuereinheit als Bestätigung die Steuerinformation seriell an die Steuereinrichtung zurück. Die Steuereinrichtung prüft ihrerseits die empfangene mit der gesendeten Information und setzt bei Gleichstand auf der dritten Datenleitung die Übernahmeinformation.

Sind die 16-Bit-Informationen ungleich, so wird eine erneute Datenübermittlung vorgenommen; wenn nötig bis zu 4 Mal. Ist dann immer noch keine Übereinstimmung erreicht, erfolgt die Abschaltung des Walzenladers bei gleichzeitiger Meldung „Übertragung gestört".

Folgende Informationen werden übertragen:

Von der Steuereinrichtung zum Ausbaugestell

a) Steuerfunktion vor der Hangendwalze
   Kohlenstoßspreize einfahren
   Anstellkappe entlasten
   Vorpfändkappe einfahren
   Anstellkappe auflasten
b) Steuerfunktion hinter der Hangendwalze
   Anstellkappe entlasten
   Vorpfändkappe ausfahren
   Anstellkappe auflasten
c) Steuerfunktion hinter der Liegendwalze
   Kohlenstoßspreize ausfahren

Vom Ausbaugestell zur Steuereinrichtung

a) Kohlenstoßspreize eingefahren
b) Vorpfändkappe eingefahren

Aus dem Informationscode werden die einzelnen Steuerfunktionen bzw. Abläufe gebildet und damit die einzelnen Magnetventile angesteuert.

Zwischen den einzelnen Steuereinheiten werden jeweils zwei eigensichere Leitungen geführt, und zwar eine für die Spannungsversorgung der Magnetventile, die andere für die Übertragung der Steuerfunktion. Alle Anschlüsse sind steckbar aufgeführt, ebenso die Verbindungen zwischen den Steuereinheiten und den Magnetventilen.

Technische Daten:

Netzspannung:	42 V, 50-60 Hz
Ausgangs-Stromkreise (eigensicher)	
Spannung:	12 V-
Stromstärke:	bis 1,8 A
Schaltstromkreise (nicht eigensicher)	
Spannung:	bis 42 V
Stromstärke:	bis 3 A
Leistung:	bis 200 VA/80 W
Magnetventile (eigensicher)	
Spannung:	12 V-
Stromstärke:	bis 0,75 A
Schutzarten nach VDE 0170	(Sch)e (Sch)s (Sch)i
nach DIN 40050	IP 54

Bescheinigung G.Ä-Nr. 8/82 v. 18. 2. 1982

A 16-bit data item is serially transmitted via a 3-wire transmission line to all chocks; it is checked and evaluated in the control units of the chocks. Before the function is performed, the control unit transmits the control information as a confirmation serially back to the control device. The control device in turn compares the information received with the information transmitted and, if both are in accordance, it applies the acceptance information on to the third data line.

In the case of an inequality of the 16-bit information sets, a new data transmission takes place and, if necessary, this is repeated up to 4 times. If a consistency is then still not reached, the shearer loader is switched off and at the same time the signal "transmission out of order" is given.

The following information is transmitted:

From the control device to the chock

a) control function in front of the roof drum
   - lower anti-spalling device
   - release front cantilever
   - lower fore-pole
   - set front cantilever
b) control function behind the roof drum
   - release front cantilever
   - extend fore-pole
   - set front cantilever
c) control function behind the floor drum
   - extend anti-spalling device

From the chock to the control device

a) anti-spalling device retracted
b) fore-pole retracted.

The information code provides the different control functions respectively operations to trigger the solenoid valves.

The individual control units are connected by two intrinsically safe cables, one serving for power supply to the solenoid valves, and the other one for transmitting the control function. All connections are of the plug-in type, same as the connections between the control units and the solenoid valves.

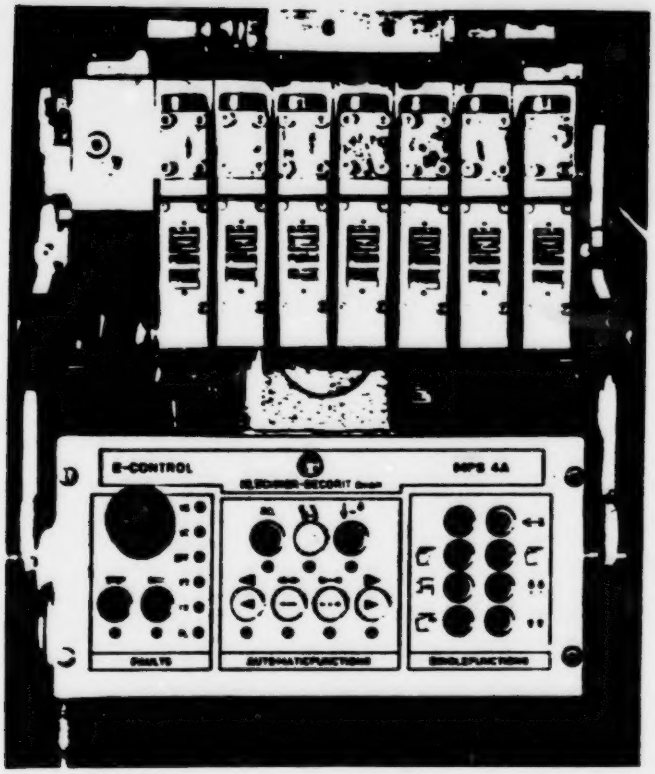
Technical Data:

Mains voltage:	42 V, 50-60 Hz
Output circuits (intrinsically safe)	
Voltage:	12 V-
Amperage:	up to 1,8 A
Switching circuits (non intrinsically safe)	
Voltage:	up to 42 V
Amperage:	up to 3 A
Capacity:	up to 200 VA/80 W
Solenoid valves (intrinsically safe)	
Voltage:	12 V-
Amperage:	up to 0,75 A
Protection classes according to VDE 0170:	(Sch)e (Sch)s (Sch)i
according to DIN 40050:	IP 54

Certificate G.Ä-No. 8/82 dated 18. 2. 1982

KLOECKNER-BECORIT/North America Inc.

Technical Information



Electro-hydraulic Roof-support control system MPS 4A

The system has been developed for the following four operating modes:

A. Shield floating batch control
B. Shield control initiated by shearer
C. Electrical Bi-di manual control
D. Manual in-unit control for all functions

See Page 2 for System Description

KLOECKNER-BECORIT/North America Inc.
255 Berry Road, Washington, PA 15301
Telephone: 412-225-4049 Fax: 412-228-2177 Telex: 902-916

The following text briefly describes the hardware and software logic used for roof support control:

A. Shield Floating Batch Control

1. **Ability to advance shields in maximum pre-set range of units from remote support operator.**
2. **Ability to push conveyor in maximum pre-set range of units with preset safety range being maintained between first shield ram pushed and last shield advanced.**
3. **Shield Advance Cycle**
    - **a) Prestart audio/visual warning (or approximately 3-4 seconds) (cycle time not affected)**
    - **b) Power lower legs by separate solenoid valve for approximately 1-2 seconds (adjustable by parameter unit)**
    - **c) Advance shield by separate solenoid valve, start after preset time delay after initiation of (b)**
    - **d) Legs set, initiated by magnetic switch (KB-DS4) at advance ram (after approximately 90% of full stroke)**

    The cycle time is 7-10 seconds. In case the advance function (c) was not completed within a preset time, the power lower functions will be repeated twice. The shield will then be set if the advance ram stroke has not been completed. The sequence is adjustable by the Headgate Parameter Unit KB—PU 1.

    Cycle initiation for the next shield is leg pressure controlled (120 bar adjustable). At that point, a positive set function is maintained for 10 seconds.

B. Shield Control Initiated by Shearer (Headgate Computer required)

In this control mode, the functions are:

- **— Lower legs**
- **— Shield advance**
- **— Legs set**

  and
- **— Conveyor push**

These functions are automatically performed based on control commands by the headgate computer based on shearer location and traveling direction.

C. Bi-Di Manual Electrical Control

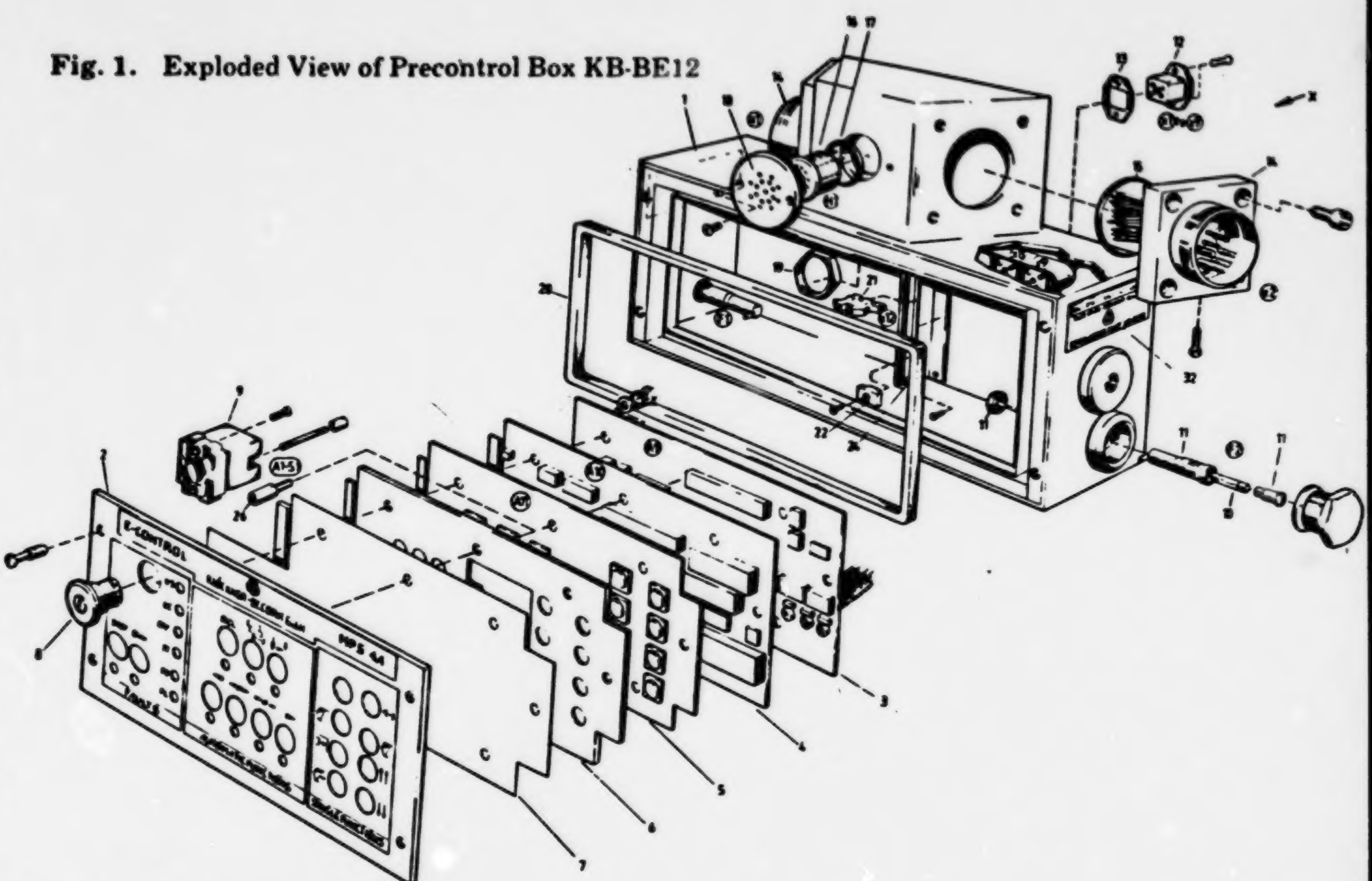
For 1 shield (left or right) Typical Functions are as follows:

1. **Legs set**
2. **Legs lower**
3. **Conveyor push**
4. **Shield advance/Base lift**
5. **Shield cycle (legs lower/shield advance/legs set)**

Other functions available as an option.

D. In Unit Manual (hydraulic only)

Fig. 1. Exploded View of Precontrol Box KB-BE12


1
2
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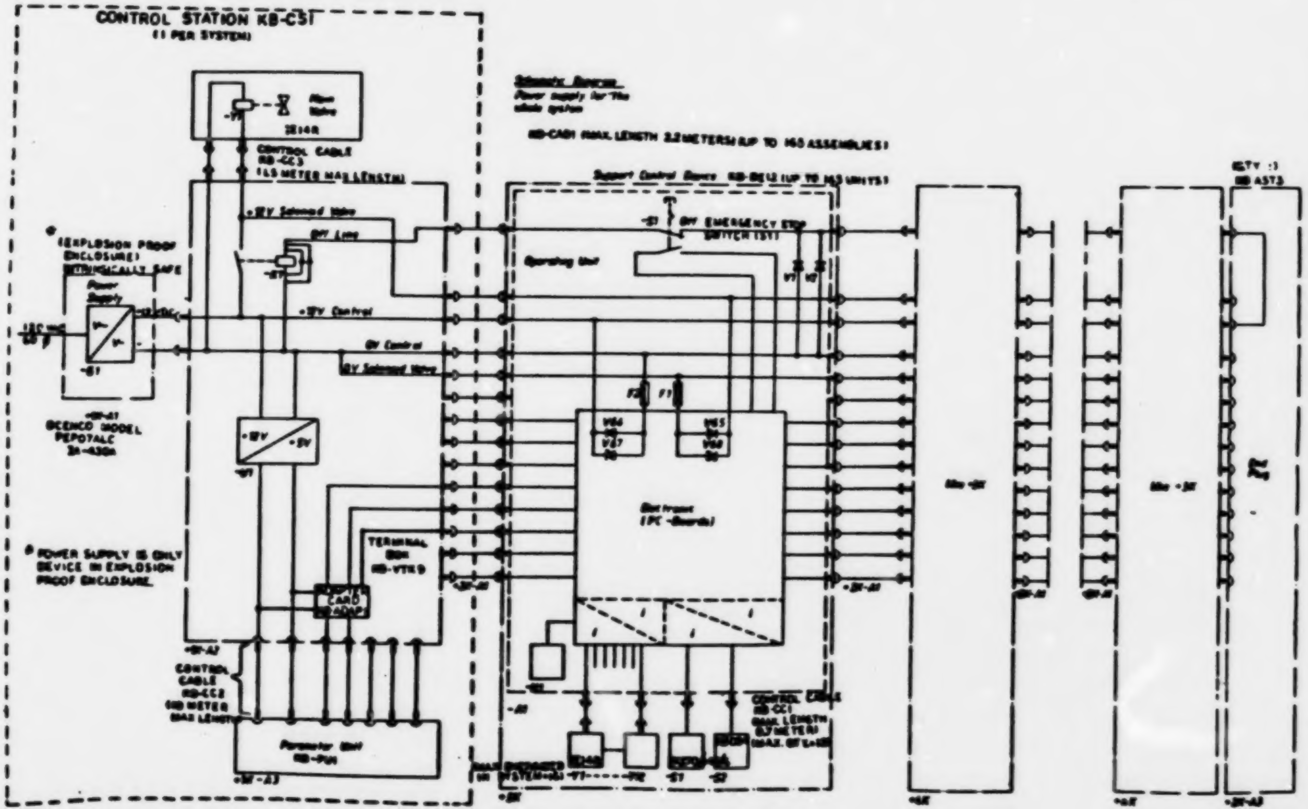
32
E-CONTROL

Fig. 2. Typical Electro-Hydraulic System Schematic


CONTROL STATION KB-CS1
(1 PER SYSTEM)
CONTROL CABLE
KB-CC3
(1.5 METER MAX LENGTH)
+12V Solenoid Valve
0V Line
(EXPLOSION PROOF ENCLOSURE) INTRINSICALLY SAFE
Power Supply
+12V Control
0V Control
0V Solenoid Valve
+12V
+5V
TERMINAL BOX
KB-VTKD
CARD
* POWER SUPPLY IS ONLY DEVICE IN EXPLOSION PROOF ENCLOSURE
CONTROL CABLE
KB-CC2
(10 METER MAX LENGTH)
Parameter Unit
KB-PU1
KB-CAD1 (MAX. LENGTH 2.2 METERS)(UP TO 165 ASSEMBLIES)
Support Control Boxes KB-BE12 (UP TO 165 UNITS)
0V EMERGENCY STOP SWITCH (S1)
Operating Unit
V7
V2
F2
F1
V64
V67
V65
V68
Electronic (PC-Boards)
CONTROL CABLE
KB-CC1
MAX LENGTH
(1.7 METER)
QTY :1
KB-AST3

Kloeckner-Becorit Electro-hydraulic controls facilitate fully automated operation of shields, face conveyor and shearer. The intrinsically safe microprocessor-based control system can continuously monitor the shearer position along the face and control the advance of shields and conveyor in the bi-directional automated operating mode. Special emphasis is being placed on flexibility and a rugged design for dependable operation and simple maintenance procedures. The hydraulic control components have been proven in many years of operation in KBNA's successful pilot operated controls. The electric components are fully encapulated against dust and water for protection when shields are hosed down for cleaning purposes.

SYSTEM DESIGN FEATURES

- Microprocessor in each support for maximum flexibility
- Proven Kloeckner-Becorit pilot valve system with low maintenance "ball seat" pilot valves
- Less sensitive to dust (only 100 micron filtration required)
- Easily accessible components for exchange
- DN 12 (½") valve ports for hoses
- Modular cartridge component replacement for pilot and full flow valves
- Easily retrofitable from full hydraulic to electro-hydraulic, KBNA has sold hydraulic system with this requirement
- MSHA approved (IA-448)
- Spray proof (to DIN standard iP 65)
- Large return (DN 25 (1")) and pressure (DN 20 (¾")) ports on full flow valve
- Hydraulic lock-on conveyor push
- Advance ram equipped with low maintenance proximity switch (externally mounted)
- Simple parameter unit for changing software variables
- Fault analysis panel on each support
- Single power supply system with U.S. supplier
- Retrofittable to other roof support manufacturers.

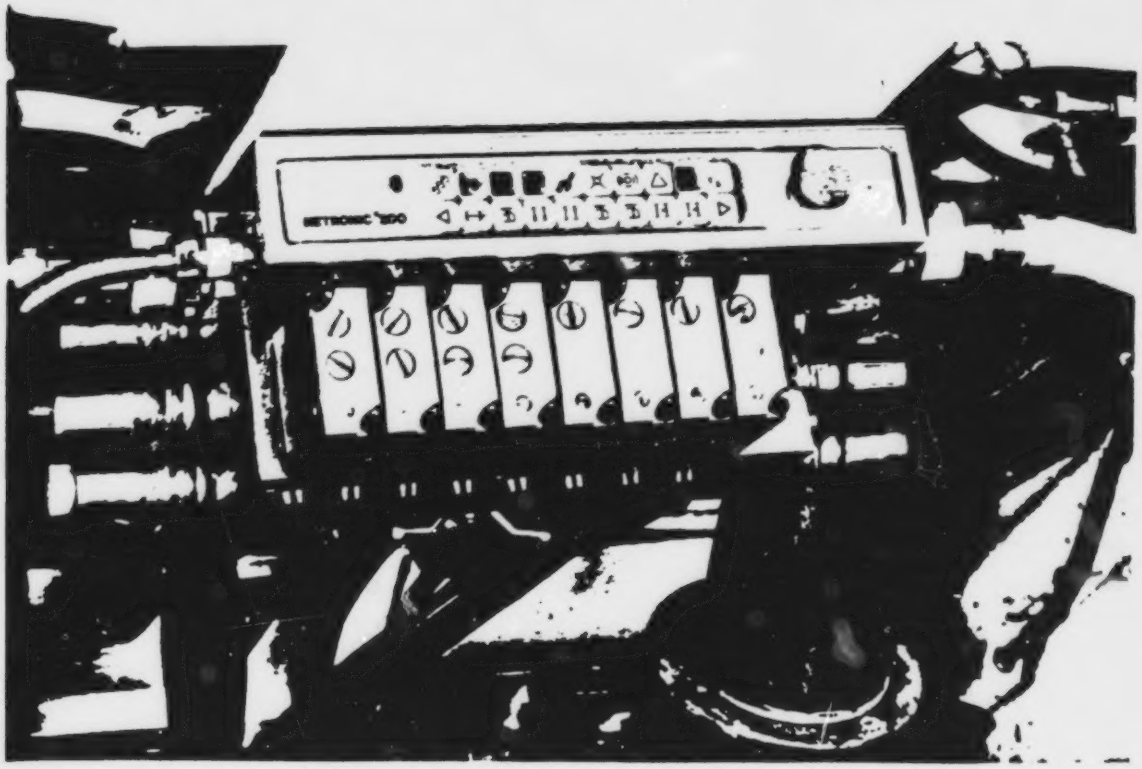
KLOECKNER-BECORIT/North America Inc.
255 Berry Road, Washington, PA 15301
Telephone: 412-225-4049 Fax: 412-228-2177 Telex: 902-916

10 86

MASCHINENFABRIK

HETRONIC® 200/308

HEMSCHEIDT
HETRONIC® 200



HEMSCHEIDT-Schild G 550 9,9/18,3 mit HETRONIC® 200/308
— Kompakte Flachbauweise für Strebe mit geringer Mächtigkeit —

HETRONIC® 200/308
eigensichere elektro-hydraulische Steuereinheit

HETRONIC® 200/308

Entwicklung
Software
Konstruktion
Fertigung

Diese Steuereinheit ist im Modul-System konstruiert und kompatibel mit

HETRONIC® 200/008 HETRONIC® 200/408
HETRONIC® 200/108 HETRONIC® 200/412
HETRONIC® 200/208 HETRONIC® 200/812
HETRONIC® 200/308 hydraulischer Signal- und Ablaufsteuerung

HEMSCHEIDT-shield G 550 9,9/18,3 with HETRONIC® 200/308
— compact flat pack design for thin seams

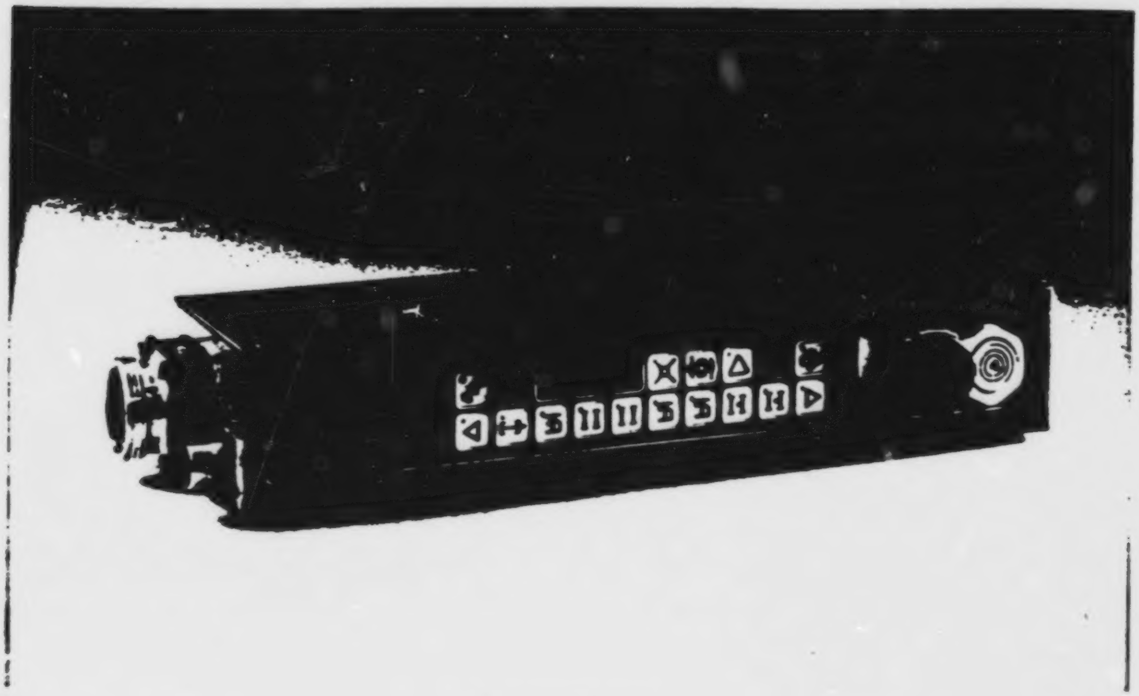
HETRONIC® 200/308
intrinsically safe electro hydraulic control unit

HETRONIC® 200/308

Developed ***by HEMSCHEIDT***
Software ***by HEMSCHEIDT***
Designed ***by HEMSCHEIDT***
Manufactured ***by HEMSCHEIDT***

The control unit is designed as a modular system and compatible with

HETRONIC® 200/008 *HETRONIC® 200/408*
HETRONIC® 200/108 *HETRONIC® 200/412*
HETRONIC® 200/208 *HETRONIC® 200/812*
HETRONIC® 200/308 ***hydraulic signal and sequence control***



HETRONIC® 200/308

Steuergerät HETRONIC® 200/308
Bi-di Steuerung aller Einzelfunktionen ★ bi-di Ablaufsteuerung ★ bi-di Gruppensteuerung, gleitende Gruppen mit Ausbau vorziehen und Förderer rücken ★ Fördererandruck und Nachsetzen ★ Zustandsanzeigen ★ Sperrschalter für den einzelnen Schild und bei Gruppensteuerung für die gesamte Gruppe.

Flexibilität

★ Bei Verwendung einer HETRONIC® 200/2000 Parameterstation können die Betriebsparameter verändert werden. Hierdurch kann das System optimal an die Abbaubedingungen angepaßt werden.

★ Anschlußmöglichkeit für periphere Analoggeber für Weg und Druck.

★ Kompatibel zum Zentralgerät HETRONIC® 200/3000 zum Steuern des Ausbaus ausgelöst durch den Walzenlader.

★ Ausgelegt für Steuern und Überwachen von über Tage.

Stromversorgung
Nur eine Stromversorgung in der Strecke für den gesamten Streb ★ nur ein Elektrokabel von Schild zu Schild.

Sicherheit
Sperrschalter ★ Übersteuern aller Funktionen jederzeit durch Handbetätigungshebel möglich ★ eigensichere Hardware, Elektromagneten, Kabel und Stromversorgung.

Staubbelästigung
Die Gruppensteuerung wird vom Schildrücker in der staubfreien Zone betätigt oder durch den Walzenlader ausgelöst.

Zuverlässigkeit
Im Untertage-Einsatz erprobt ★ komplett abgedichtetes Steuergerät ★ Elektromagnetventil, erfolgreich getestet mit mehr als 2 Millionen Schaltungen bei 350 bar.

Control unit HETRONIC® 200/308
Bi-directional control of all single functions ★ bi-directional sequence control ★ bi-directional batch control consisting of conveyor push and support sequence control ★ bank push and positive set ★ operational phase indicators ★ emergency stop for a single shield and in case of batch control for the whole group.

Flexibility

★ Using a HETRONIC® 200/2000 parameter unit a computer programmed mode change can be done. This provides optimum adaption to the mining conditions.

★ Combination with conveyor distance and pressure sensors.

★ Compatibel to the central unit HETRONIC® 200/3000 for shearer initiated support control.

★ Suitable for face control from surface.

Power supply
Only one power supply located at the headgate for operating the entire face ★ only one electric cable from shield to shield.

Safety
Emergency stop ★ overriding of all functions at any time using manual control levers ★ intrinsically safe hardware, solenoids, cables and power supply.

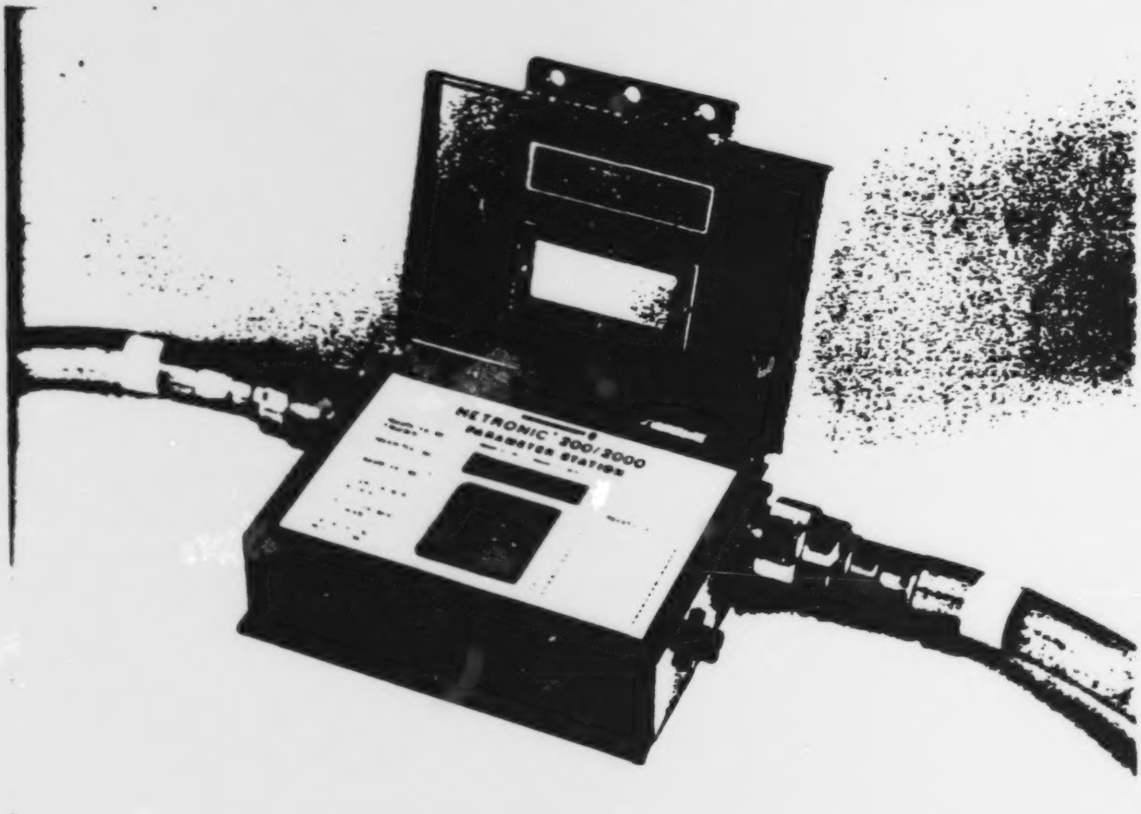
Health
Batch control is activated by the operator from a dustfree area or by the shearing machine.

Reliability
Experience in underground operation ★ totally sealed control unit ★ solenoid-pilot valve unit tested with 350 bar more than 2 million times.

MASCHINENFABRIK

HEMSCHEIDT
HETRONIC® 200

HETRONIC® 200/2000
Parameter Station
Parameter Unit



HETRONIC® 200/2000 Parameterstation

HETRONIC® 200/2000 Parameter Unit

HETRONIC® 200/2000 Parameterstation

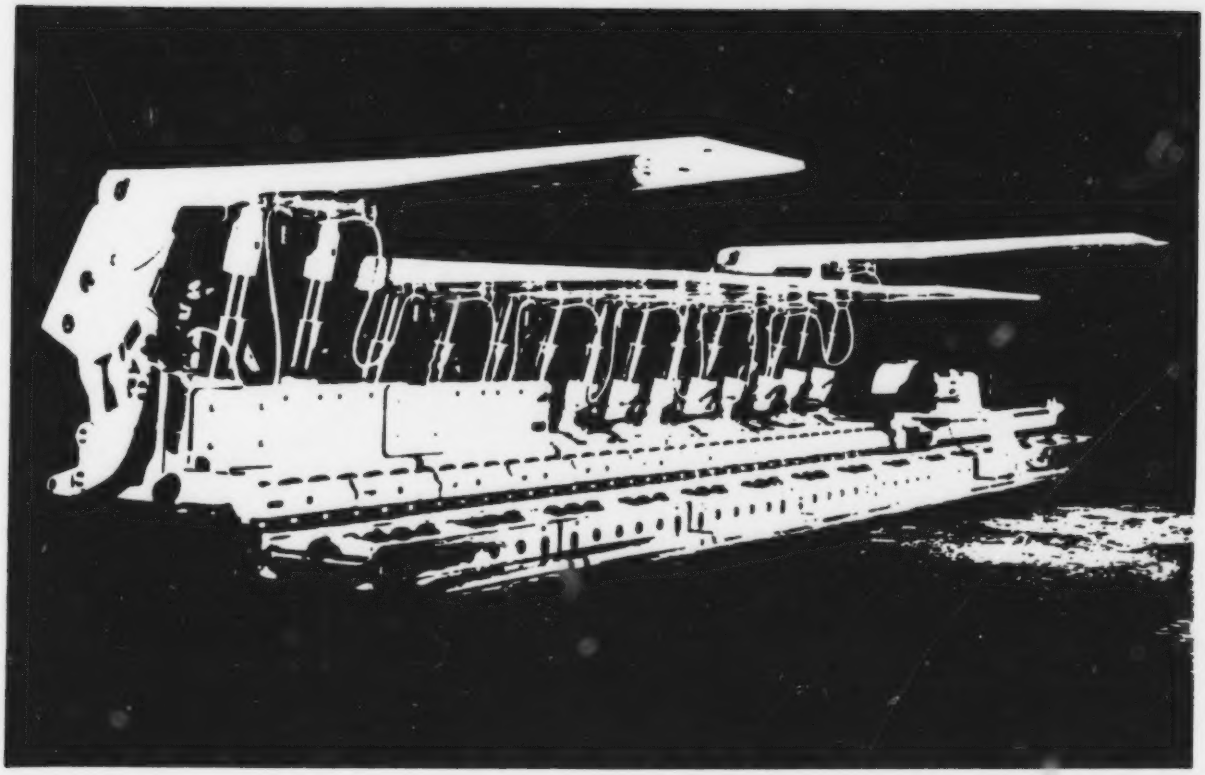
Automatischer Aufruf aller HETRONIC® 200 Geräte im Streb ★ optimale Anpassung der Anlage an die Strebverhältnisse ★ zentrale Parameteränderung über Tastatur ★ Anzeige im Display, zum Beispiel
- Rauben
- Schreiten
- Setzen
- Gruppengröße
- akustische Warnung.

Zentrales Einschalten für Förderer rücken im gesamten Streb

HETRONIC® 200/2000 Parameter Unit

Automatic checking of all HETRONIC® 200 units throughout the face ★ optimal adaptation to mining conditions ★ the keyboard offers the capability to change the operational parameters such as
- *leg lowering*
- *support advance*
- *leg setting*
- *size of group*
- *audible warning.*

Centrally located switch-on capability for conveyor push function throughout the entire face.



HEMSCHEIDT-Schild G 550-9.9/18.3 mit HETRONIC® 200/408

Steuergerät HETRONIC® 200/408
Bi-di Steuerung aller Einzelfunktionen ★ bi-di Ablaufsteuerung ★ bi-di Gruppensteuerung, gleitende Gruppen mit Ausbau vorziehen und Förderer rücken ★ Födererandruck und Nachsetzen ★ Zustandsanzeigen ★ Sperrschalter für den einzelnen Schild und bei Gruppensteuerung für die gesamte Gruppe.

Flexibilität
★ Bei Verwendung einer HETRONIC® 200/2000 Parameterstation können die Betriebsparameter verändert werden. Hierdurch kann das System optimal an die Abbaubedingungen angepaßt werden.

★ Anschlußmöglichkeit für periphere Analoggeber für Weg und Druck.

★ Kompatibel zum Zentralgerät HETRONIC® 200/3000 zum Steuern des Ausbaus ausgelöst durch den Walzenlader.

★ Ausgelegt für Steuern und Überwachen von über Tage.

Stromversorgung
Nur eine Stromversorgung in der Strecke für den gesamten Streb ★ nur ein Elektrokabel von Schild zu Schild.

Sicherheit
Sperrschalter ★ Übersteuern aller Funktionen jederzeit durch Handbetätigungshebel möglich ★ eigensichere Hardware, Elektromagneten, Kabel und Stromversorgung.

Staubbelästigung
Die Gruppensteuerung wird vom Schildrücker in der staubfreien Zone betätigt oder durch den Walzenlader ausgelöst.

Zuverlässigkeit
Im Untertage-Einsatz erprobt ★ komplett abgedichtetes Steuergerät ★ Elektromagnetventil, erfolgreich getestet mit mehr als 2 Millionen Schaltungen bei 350 bar.

HEMSCHEIDT shield G 550-9.9/18.3 with HETRONIC® 200/408

Electronic control HETRONIC® 200/408
Bi-directional control of all single functions ★ bi-directional sequence control ★ bi-directional batch control for conveyor push and support sequence ★ bank push and positive set ★ operational mode indicators ★ emergency lock out switch for single shield, and, in case of batch control, for the entire group.

Versatility
Using the HETRONIC® 200/2000 parameter unit, a computer program mode change can be executed. This provides optimal adaptation to the mining conditions ★ can be used in conjunction with the shield advance and leg pressure sensors ★ compatible to central unit HETRONIC® 200/3000 for shearer initiated support control ★ suitable for face control from surface.

Power supply
Only one power supply located at the head gate for operating the entire face ★ only one electric cable between shields.

Safety
Emergency lock out switch ★ manual override of all functions, at any time, using control levers ★ intrinsically safe hardware, solenoids, cables and power supply.

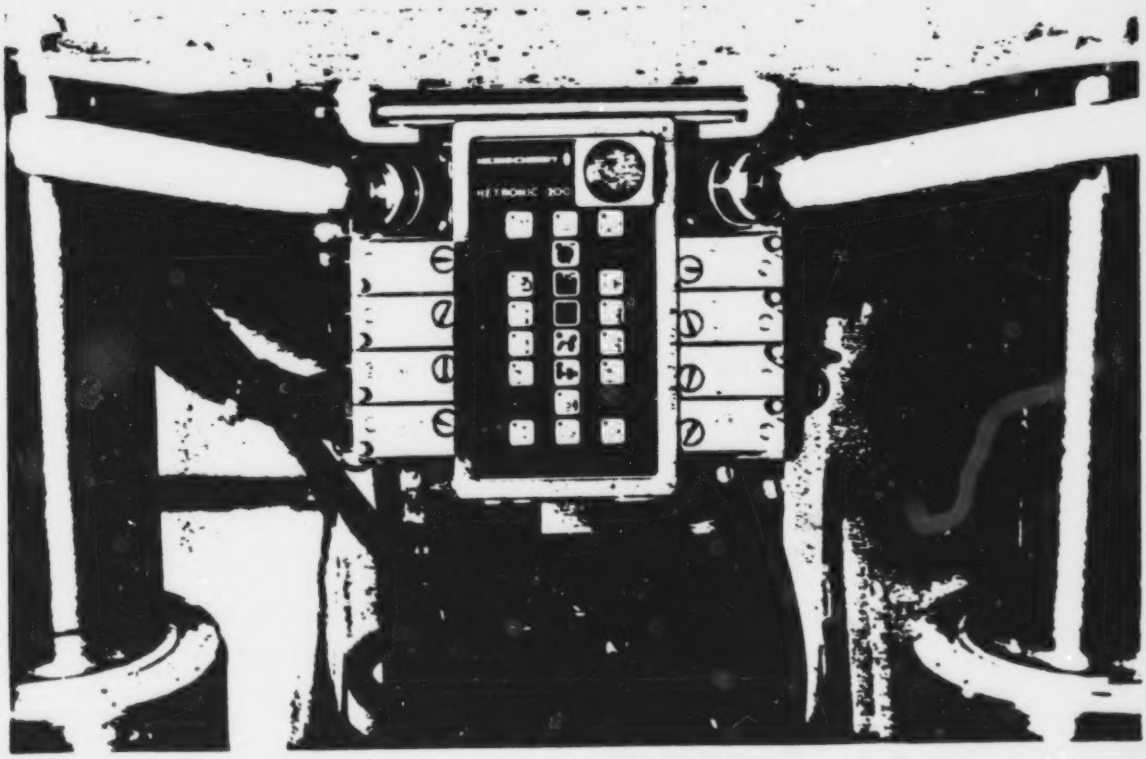
Dust protection
Batch control is activated either by the operator from a dust-free area or by the shearing machine.

Reliability
Experience in underground operation ★ totally sealed control unit ★ solenoid-pilot valve unit tested with 350 bar more than 2 million times.

MASCHINENFABRIK

HETRONIC® 200/408

HEMSCHEIDT
HETRONIC® 200



HETRONIC® 200/408
eigensichere elektrohydraulische Steuereinheit

HETRONIC® 200/408
intrinsically safe electro hydraulic control unit

HETRONIC® 200/408

Entwicklung
Software
Konstruktion
Fertigung

HETRONIC® 200/408

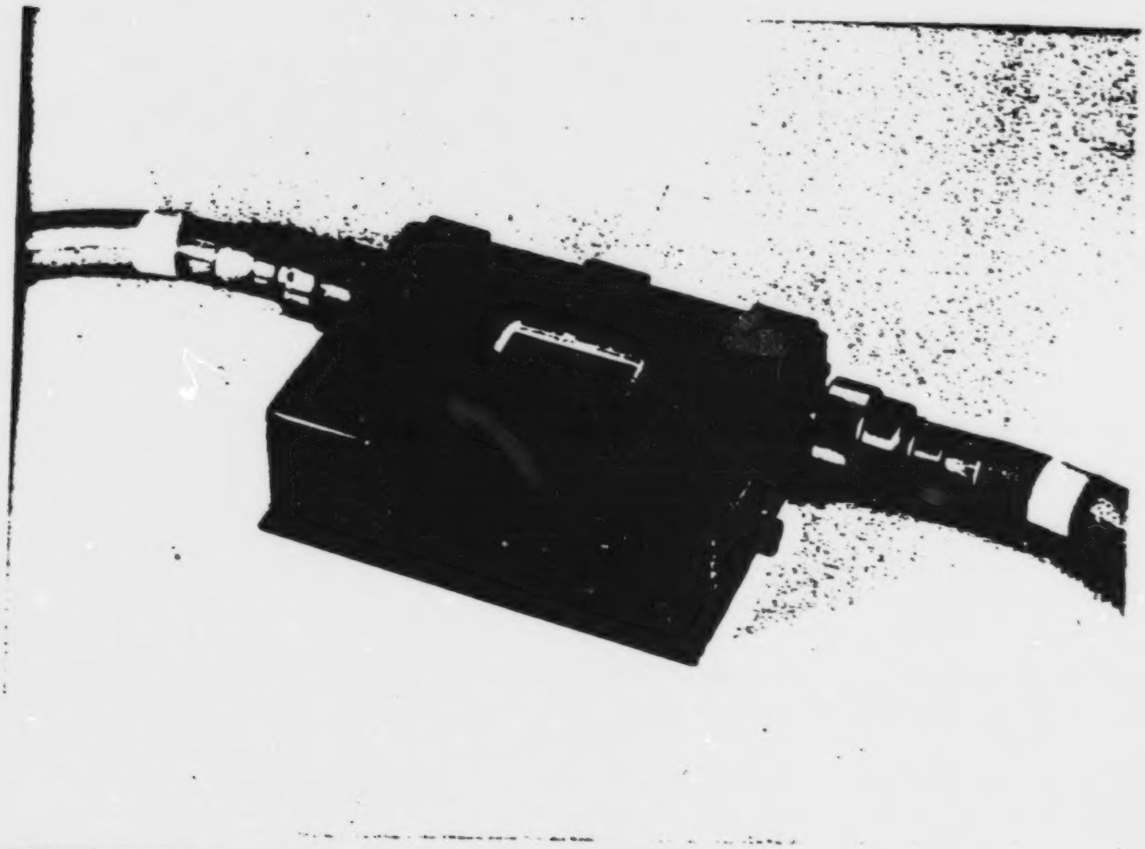
Developed	***by HEMSCHEIDT***
Software	***by HEMSCHEIDT***
Designed	***by HEMSCHEIDT***
Manufactured	***by HEMSCHEIDT***

Diese Steuereinheit ist im Modul-System konstruiert und kompatibel mit:

HETRONIC® 200/008	HETRONIC® 200/408
HETRONIC® 200/108	HETRONIC® 200/412
HETRONIC® 200/208	HETRONIC® 200/812
HETRONIC® 200/308	hydraulischer Signal- und Ablaufsteuerung

The control unit is designed as a modular system and compatible with:

HETRONIC® 200/008	*HETRONIC® 200/408*
HETRONIC® 200/108	*HETRONIC® 200/412*
HETRONIC® 200/208	*HETRONIC® 200/812*
HETRONIC® 200/308	*hydraulic signal and sequence control*



HETRONIC® 200/2000 Parameterstation

Flexibilität
Die Parameterstation kann alle wichtigen Betriebsparameter in den HETRONIC® 200 elektro-hydraulischen Ausbausteuergeräten ändern und den automatischen Ablauf der Ausbaue optimal an die Abbaubedingungen anpassen.

Stromversorgung
Anschluß an die zentrale, eigensichere Stromversorgung der HETRONIC® 200-Anlage.

Sicherheit
Eigensichere Hardware der
— Parameterstation
— Steuergeräte
— Hetronic® 200
— Elektromagnete und Stromversorgung.
Keine unbefugte Bedienung durch elektronisches Zahlenschloß ★ Beeinflussung sicherheitsrelevanter Einrichtungen ausgeschlossen.

Zuverlässigkeit
Im Untertage-Einsatz erprobt ★ Eingabe über eine bergbaubewährte Flachtastatur ★ komplett abgedichtetes Gerät ★ keine bewegten Teile.

HETRONIC® 200/2000 Parameter Unit

Versatility
Using the HETRONIC® 200 parameter station, all major operational parameters can be changed throughout the face in order to achieve optimal adaptation to the mining conditions.

Power supply
The intrinsically safe power supply is used for both the electronic controls and parameter station.

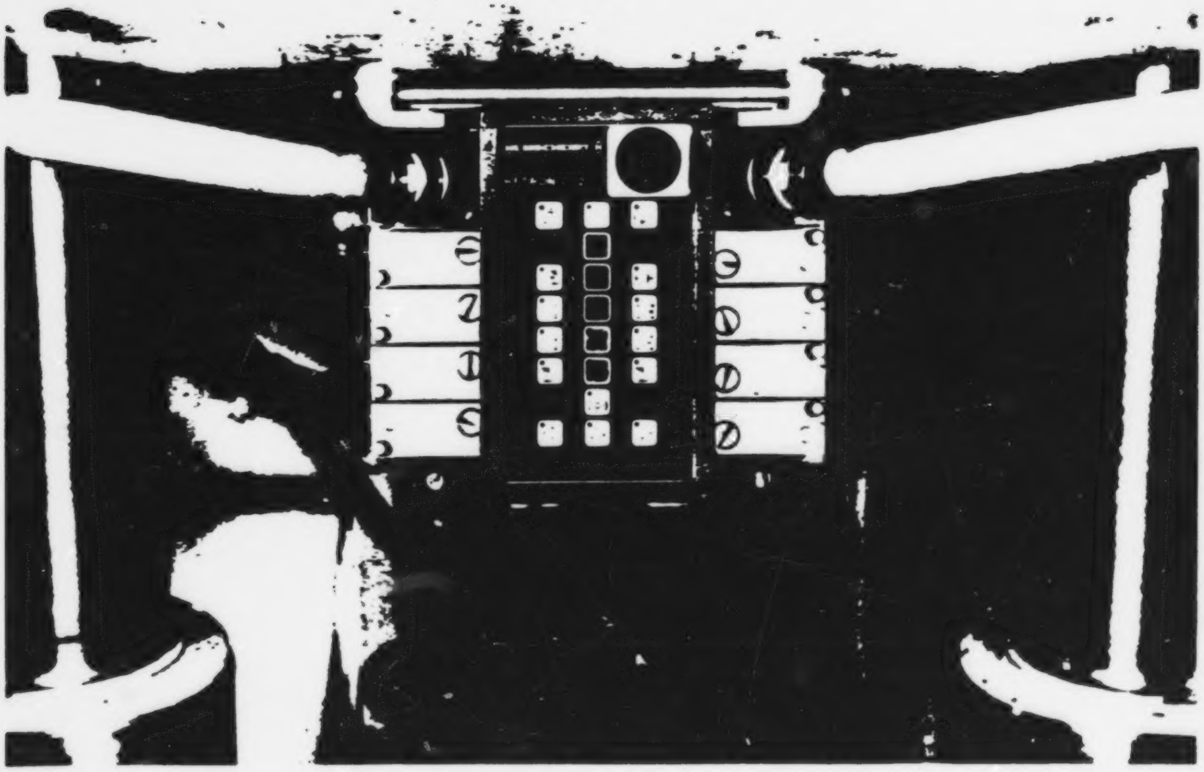
Safety
Intrisically safe hardware of the
— parameter station
— electro hydraulic control units
— Hetronic® 200
— solenoids, and power supply.
Prevention of unauthorized operation by using an electronic code.

Reliability
Experience in underground operation ★ Input using flat panel switches ★ totally sealed control unit ★ no moving parts.

MASCHINENFABRIK

HETRONIC® 200/408

HEMSCHEIDT
HETRON



HETRONIC® 200/408
eigensichere elektrohydraulische Steuereinheit

HETRONIC® 200/408
intrinsically safe electro hydraulic control unit

HETRONIC® 200/408

Entwicklung
Software
Konstruktion
Fertigung

HETRONIC® 200/408

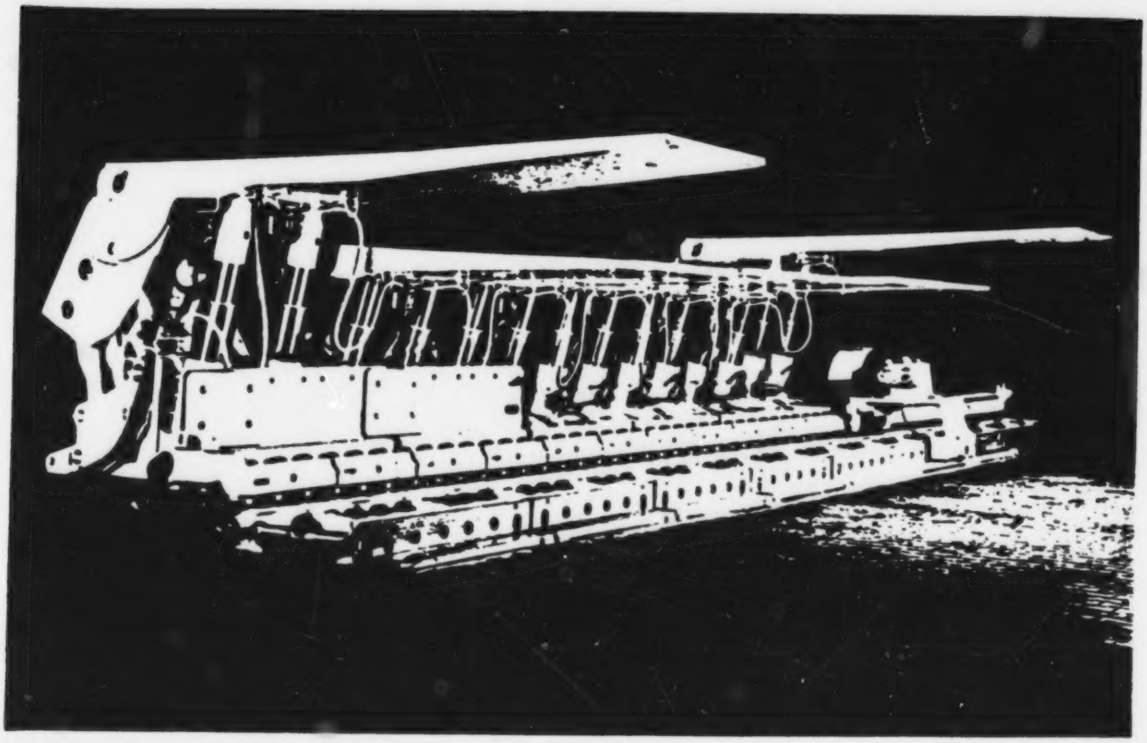
Developed by HEMSCHEIDT
Software by HEMSCHEIDT
Designed by HEMSCHEIDT
Manufactured by HEMSCHEIDT

Diese Steuereinheit ist im Modul-System konstruiert und kompatibel mit:

HETRONIC® 200/008	HETRONIC® 200/408
HETRONIC® 200/108	HETRONIC® 200/412
HETRONIC® 200/208	HETRONIC® 200/812
HETRONIC® 200/308	hydraulischer Signal- und Ablaufsteuerung

The control unit is designed as a modular system and compatible with:

HETRONIC® 200/008	*HETRONIC® 200/408*
HETRONIC® 200/108	*HETRONIC® 200/412*
HETRONIC® 200/208	*HETRONIC® 200/812*
HETRONIC® 200/308	*hydraulic signal and sequence control*



HEMSCHEIDT-Schild G 550-9.9/18.3 mit HETRONIC® 200/408

HEMSCHEIDT shield G 550-9.9/18.3 with HETRONIC® 200/408

Steuergerät HETRONIC® 200/408

Bi-di Steuerung aller Einzelfunktionen ★ bi-di Ablaufsteuerung ★ bi-di Gruppensteuerung, gleitende Gruppen mit Ausbau vorziehen und Förderer rücken ★ Fördererandruck und Nachsetzen ★ Zustandsanzeigen ★ Sperrschalter für den einzelnen Schild und bei Gruppensteuerung für die gesamte Gruppe.

Flexibilität

★ Bei Verwendung einer HETRONIC® 200/2000 Parameterstation können die Betriebsparameter verändert werden. Hierdurch kann das System optimal an die Abbaubedingungen angepaßt werden.

★ Anschlußmöglichkeit für periphere Analoggeber für Weg und Druck.

★ Kompatibel zum Zentralgerät HETRONIC® 200/3000 zum Steuern des Ausbaus ausgelöst durch den Walzenlader.

★ Ausgelegt für Steuern und Überwachen von über Tage.

Stromversorgung

Nur eine Stromversorgung in der Strecke für den gesamten Streb ★ nur ein Elektrokabel von Schild zu Schild.

Sicherheit

Sperrschalter ★ Übersteuern aller Funktionen jederzeit durch Handbetätigungshebel möglich ★ eigensichere Hardware, Elektromagneten, Kabel und Stromversorgung.

Staubbelästigung

Die Gruppensteuerung wird vom Schildrücker in der staubfreien Zone betätigt oder durch den Walzenlader ausgelöst.

Zuverlässigkeit

Im Untertage-Einsatz erprobt ★ komplett abgedichtetes Steuergerät ★ Elektromagnetventil, erfolgreich getestet mit mehr als 2 Millionen Schaltungen bei 350 bar.

Electronic control HETRONIC® 200/408

Bi-directional control of all single functions ★ bi-directional sequence control ★ bi-directional batch control for conveyor push and support sequence ★ bank push and positive set ★ operational mode indicators ★ emergency lock out switch for single shield, and, in case of batch control, for the entire group.

Versatility

Using the HETRONIC® 200/2000 parameter unit, a computer program mode change can be executed. This provides optimal adaptation to the mining conditions ★ can be used in conjunction with the shield advance and leg pressure sensors ★ compatible to central unit HETRONIC® 200/3000 for shearer initiated support control ★ suitable for face control from surface.

Power supply

Only one power supply located at the head gate for operating the entire face ★ only one electric cable between shields.

Safety

Emergency lock out switch ★ manual override of all functions, at any time, using control levers ★ intrinsically safe hardware, solenoids, cables and power supply.

Dust protection

Batch control is activated either by the operator from a dust-free area or by the shearing machine.

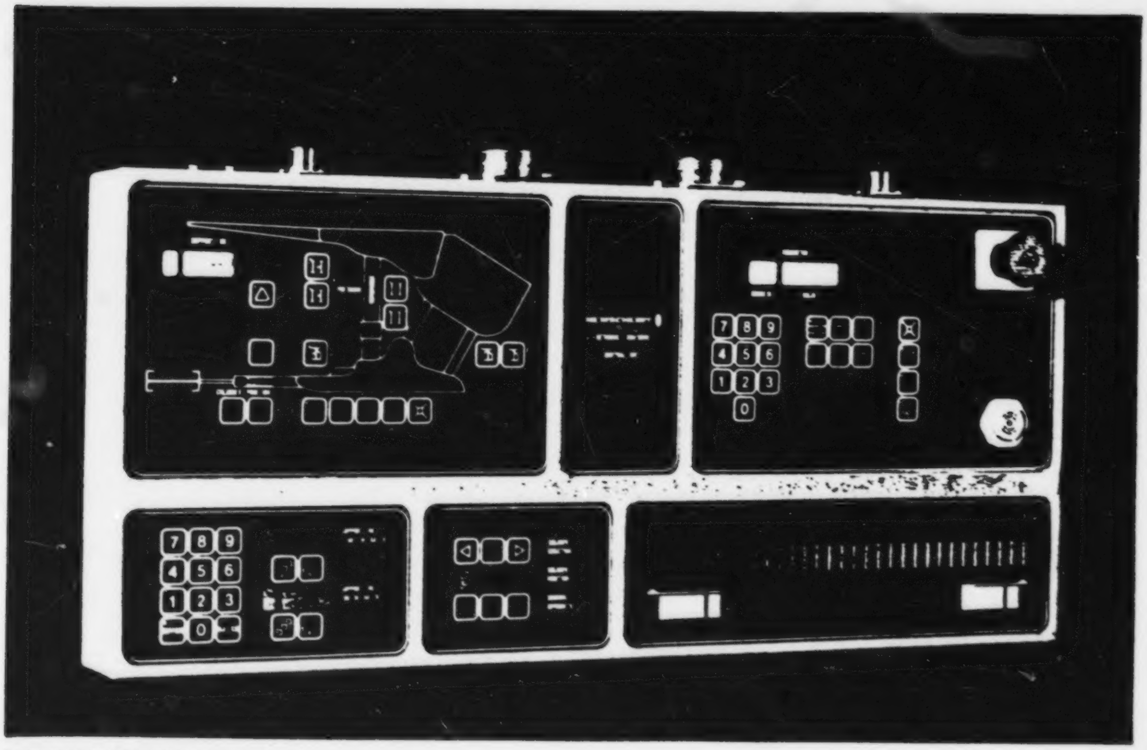
Reliability

Experience in underground operation ★ totally sealed control unit ★ solenoid-pilot valve unit tested with 350 bar more than 2 million times.

MASCHINENFABRIK

HEMSCHEIDT
HETRONIC®200

HETRONIC® 200/3000
Zentralgerät
Central Unit



HETRONIC® 200 3000 Zentralgerät

HETRONIC® 200/3000 Central Unit

HETRONIC® 200/3000 Zentralgerät

Entwicklung
Software
Konstruktion
Fertigung

Zentralgerät zum Steuern und Überwachen der Ausbaue von der Strecke aus. Einzelschildanwahl ★ Gruppenanwahl ★ Gewinnungssteuerung ★ Betriebsdatenanpassung ★ Stempeldruckanzeige ★ Schreitzylinderweganzeige ★ Walzenladerpositionsanzeige ★ Strebdarstellung über einen Bereich von 30 Schilden ★ Bedienpult mit Flachtastatur und Leuchtanzeigen ★ Schnittstelle zur Strebdatenübertragung nach über Tage ★ Überwachung von 250 Ausbauen im Streb ★ Eigensichere Hardware.

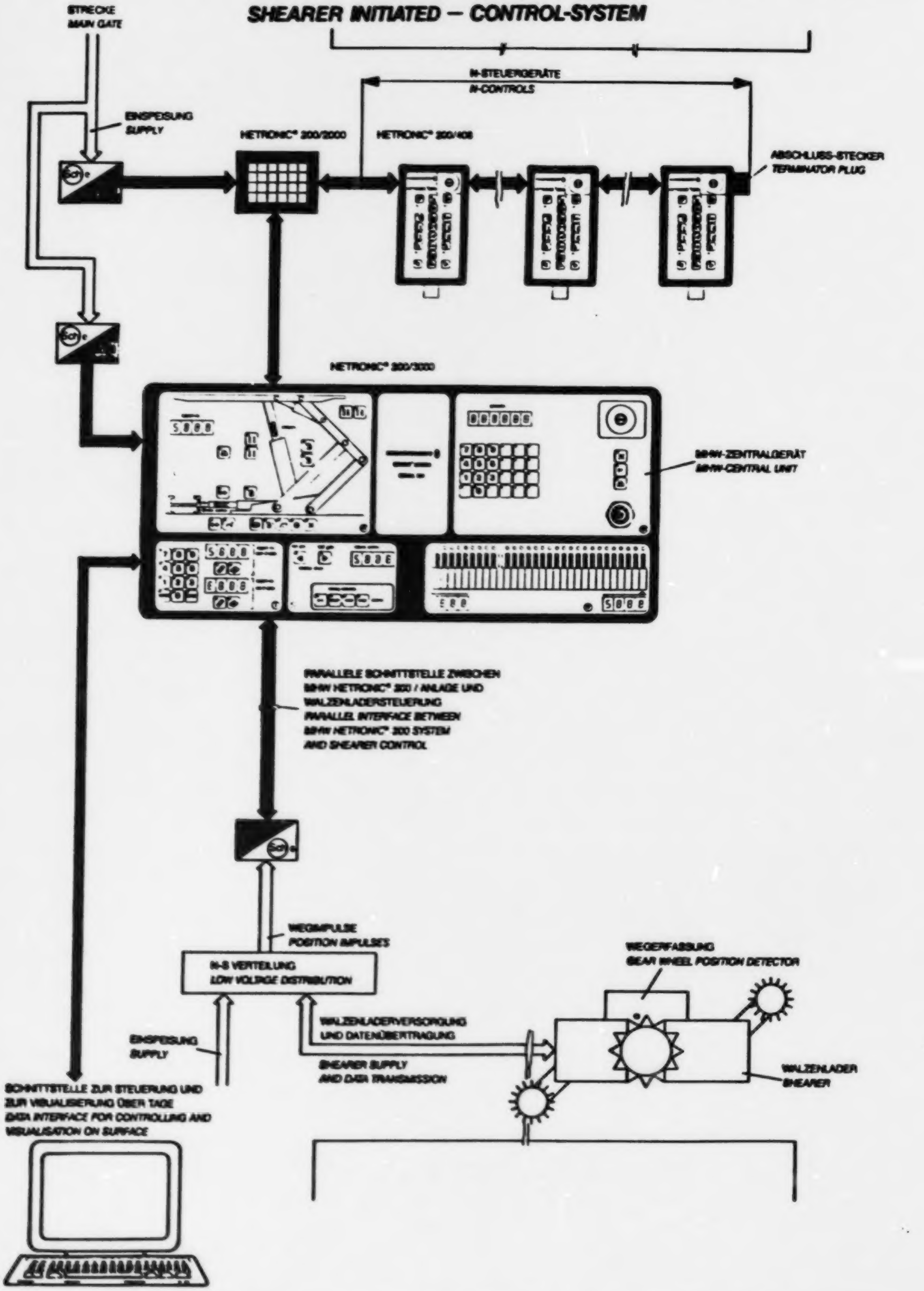
HETRONIC® 200/3000 Central Unit

Developed by HEMSCHEIDT
Software by HEMSCHEIDT
Designed by HEMSCHEIDT
Manufactured by HEMSCHEIDT

Central unit for remote support control from the entry gate. Single support control ★ and batch ★ Shearer initiated control system ★ Operating data change ★ Monitoring system ★ Cylinder position display ★ shearer position display ★ face diagram ★ keyboard with flat panel switches and illuminated displays ★ interface for face data transmission to surface ★ Controlling of 250 supports in one face ★ intrinsically safe Hardware.

GEWINNUNGSSTEUERUNG IN ABHÄNGIGKEIT VOM WALZENLAGER

SHEARER INITIATED – CONTROL-SYSTEM


STRECKE
MAIN GATE
EINSPEISUNG
SUPPLY
H-STEUERGERÄTE
H-CONTROLS
HETRONIC® 200/2000
HETRONIC® 200/408
ABSCHLUSS-STECKER
TERMINATOR PLUG
HETRONIC® 200/3000
BMHW-ZENTRALGERÄT
BMHW-CENTRAL UNIT
PARALLELE SCHNITTSTELLE ZWISCHEN
BMHW HETRONIC® 200 / ANLAGE UND
WALZENLADERSTEUERUNG
PARALLEL INTERFACE BETWEEN
BMHW HETRONIC® 200 SYSTEM
AND SHEARER CONTROL
WEGIMPULSE
POSITION IMPULSES
N-S VERTEILUNG
LOW VOLTAGE DISTRIBUTION
WEGERFASSUNG
GEAR WHEEL POSITION DETECTOR
WALZENLADERVERSORGUNG
UND DATENÜBERTRAGUNG
SHEARER SUPPLY
AND DATA TRANSMISSION
EINSPEISUNG
SUPPLY
WALZENLADER
SHEARER
SCHNITTSTELLE ZUR STEUERUNG UND
ZUR VISUALISIERUNG ÜBER TAGE
DATA INTERFACE FOR CONTROLLING AND
VISUALISATION ON SURFACE

ELECTROFLEX CONTROL SYSTEM

1. INTRODUCTION

The Electroflex control system developed by GULLICK DOBSON combines the latest computer technology with the well proven PH 5 valvegear. By using present day microprocessors and PH 5 valvegear, the resulting control system gives greater safety to personnel working on the face, better support cycling times, due to improved response times, increased reliability and the ability to control more effectively the coal face production operations by selection of the correct computer programme to suit the prevailing mining method.

Reference to figure (1) illustrates the requirements of the electronic hardware. The gate end computer with its display unit and electrical supply unit is situated in the roadway. Also with the gate end computer is the gate end unit. Mounted within each support along the coalface is an on face unit (OFU) containing a microprocessor.

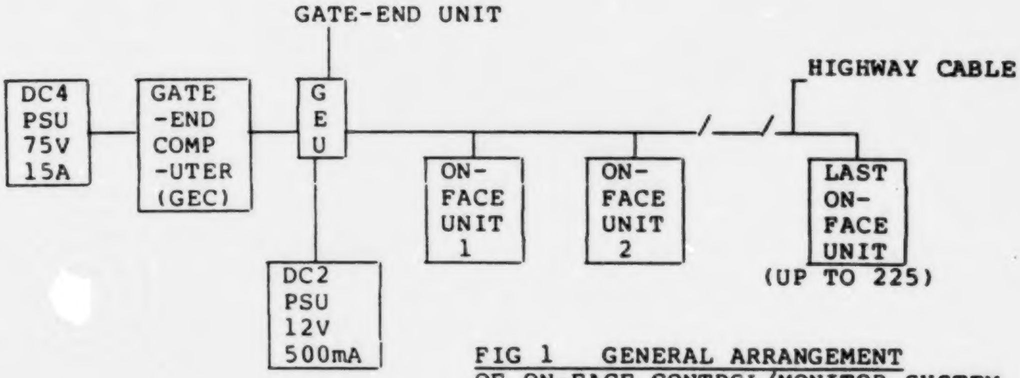

GATE-END UNIT
HIGHWAY CABLE
DC4 PSU 75V 15A
GATE-END COMPUTER (GEC)
GEU
ON-FACE UNIT 1
ON-FACE UNIT 2
LAST ON-FACE UNIT
(UP TO 225)
DC2 PSU 12V 500mA

FIG 1 GENERAL ARRANGEMENT OF ON-FACE CONTROL/MONITOR SYSTEM

This document will briefly describe each element and the resulting systems.

2. GATE END EQUIPMENT

The gate end equipment comprises the power supplies, the Gate End Computer (GEC) and the Gate End Unit (GEU).

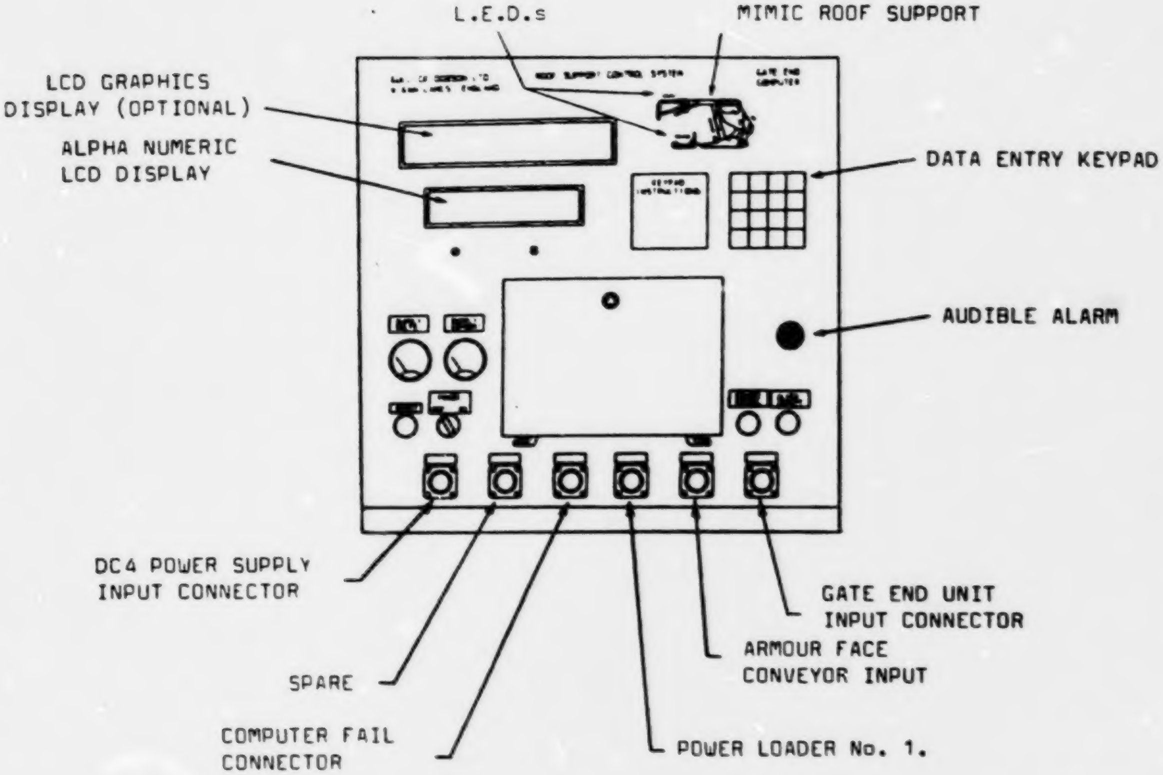
2.1. GATE END COMPUTER

The GEC is shown on figure 2.
It is an I.S. computer specifically designed to fulfill the role of a coalface control and monitoring centre. There are sufficient connectors to the computer to link the powered supports, the power pack, up to 3 shearers, the A.F.C., the stage loader, the 'general environment' and to link to the surface. Not all these links are necessary for the Electroflex control system, but have been incorporated for future monitoring purposes.

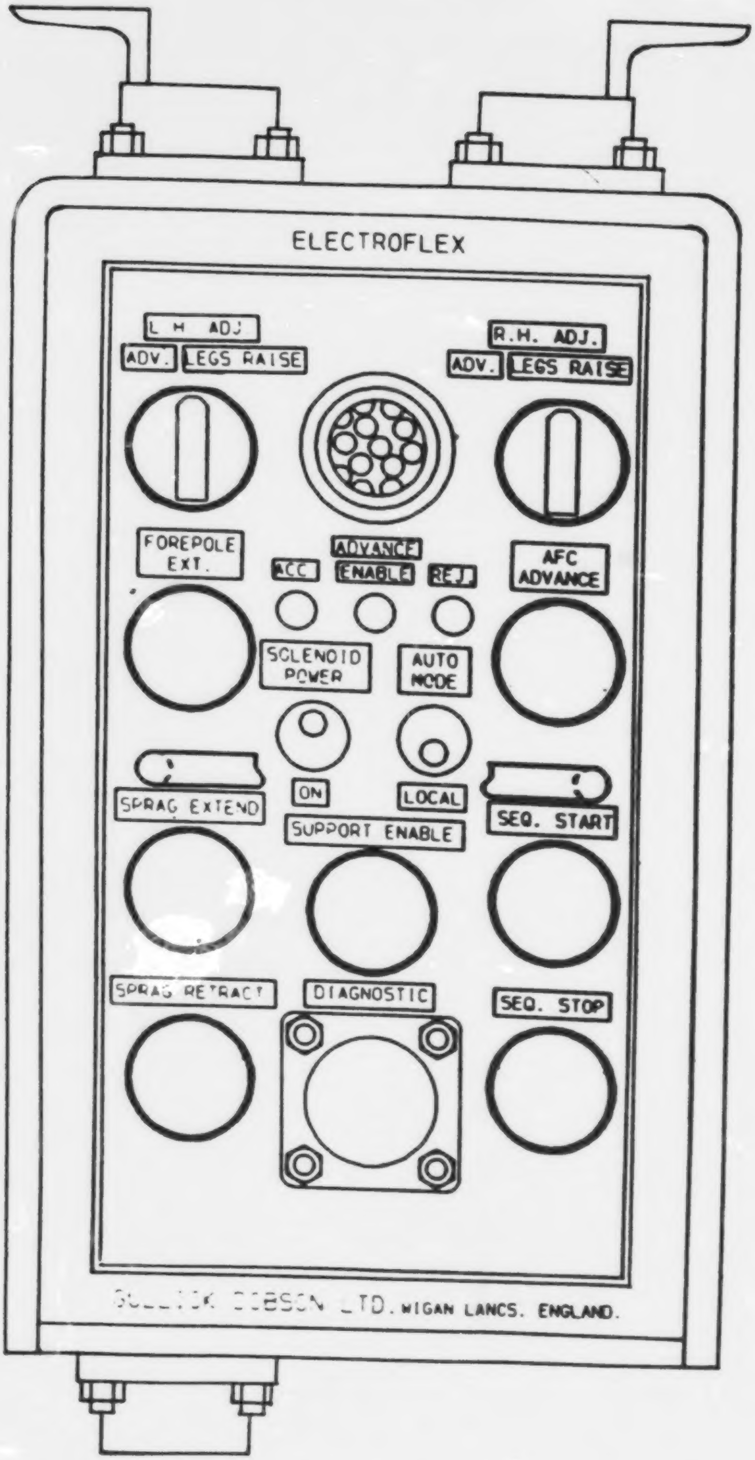
The computer has a large memory capacity comprising RAM, EPROM and EEPROM. The RAM is expandable in modules up to a maximum of 1 Mbyte. This RAM is battery supportable in the event of power failure. It would generally contain face status or monitoring data, and would be available to all operators.

The PROM contains the programmes for both control and monitoring. PROM is non volatile, and hence will be programmed in the factory. This programme will be developed in conjunction with the mining engineers associated with a particular colliery. It is Gullick Dobson's intention that each new installation will have those applications programmes developed for all previous installations. This being permanent memory, no access is needed to examine status etc.

EEPROM has the characteristic that it can be changed underground, but that, once changed, the particular parameter is permanent until rechanged. In this way it now behaves like PROM. EEPROM will be used for entering parameters which change, but only seldom. Such parameters would be headways in control, or alarm levels in monitoring. Access to EEPROM would be via security codes which would be given to colliery officials.


L.E.D.s
MIMIC ROOF SUPPORT
LCD GRAPHICS DISPLAY (OPTIONAL)
ALPHA NUMERIC LCD DISPLAY
DATA ENTRY KEYPAD
AUDIBLE ALARM
DC4 POWER SUPPLY INPUT CONNECTOR
SPARE
COMPUTER FAIL CONNECTOR
POWER LOADER No. 1.
ARMOUR FACE CONVEYOR INPUT
GATE END UNIT INPUT CONNECTOR

- GATE END COMPUTER


ELECTROFLEX
L.H. ADJ.
ADV.
LEGS RAISE
R.H. ADJ.
ADV.
LEGS RAISE
FOREPOLE EXT.
ADVANCE ENABLE
ACC.
REJ.
AFC ADVANCE
SOLENOID POWER
AUTO MODE
ON
LOCAL
SPRAG EXTEND
SUPPORT ENABLE
SEQ. START
SPRAG RETRACT
DIAGNOSTIC
SEQ. STOP
GULLICK DOBSON LTD. WIGAN LANCS. ENGLAND.

- ELECTROFLEX CONTROL UNIT

The main features of the Gate End Computer are the two keypads and the two visual displays. The upper keypad is for general use by the operators. The lower keypad has restricted access, and is where the EEPROM values are changed.

The lower VDU displays only alphanumerical values and will always be present. The upper VDU displays a graphical interpretation of data, and will normally be present in the monitoring role only.

2.2. GATE END UNIT

The GEU has three functions. The first function of the GEU is to pick up power to supply the equipment on the roof supports. The second function is to provide isolation between this power supply and that used on the GEC. The third function is to take the messages coming from the GEC, translate them into the correct format for the roof support equipment, then transmit them, and vice versa.
A general view of the GEU is shown in fig. 3.

3. ROOF SUPPORT EQUIPMENT

The equipment needed for each roof support is a set of Phase 5 valve gear (for manual override control), an On Face Unit, and an Electrohydraulic interface pack. The Phase 5 valve gear has been well described elsewhere and will not form part of this document.

3.1. ON FACE UNIT

An OFU is shown in figure 4. This is mounted next to the Phase 5 control valve. Together they form the control station for operations.

The OFU consists of a neat, compact metal box housing a series of push buttons, the highway connectors and the on face microprocessors. By selection of the appropriate buttons the hydraulic operations on the supports are activated, and a logical system of feedback to the Gate End computer is achieved. Typical sequences of operation are described in section 4.

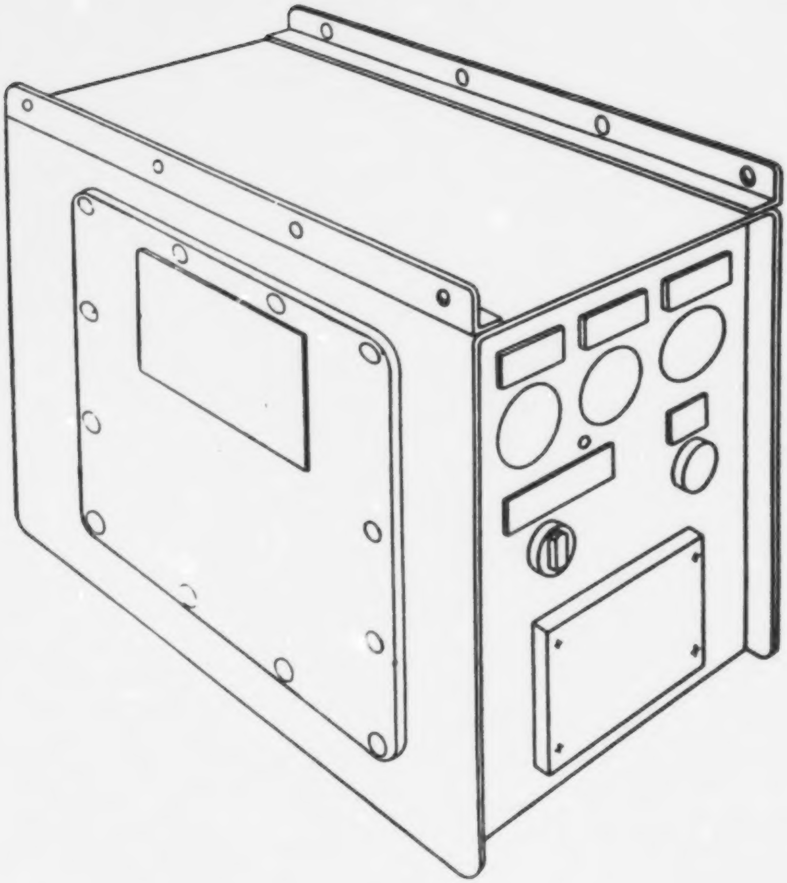


FIG 3 GATE END UNIT

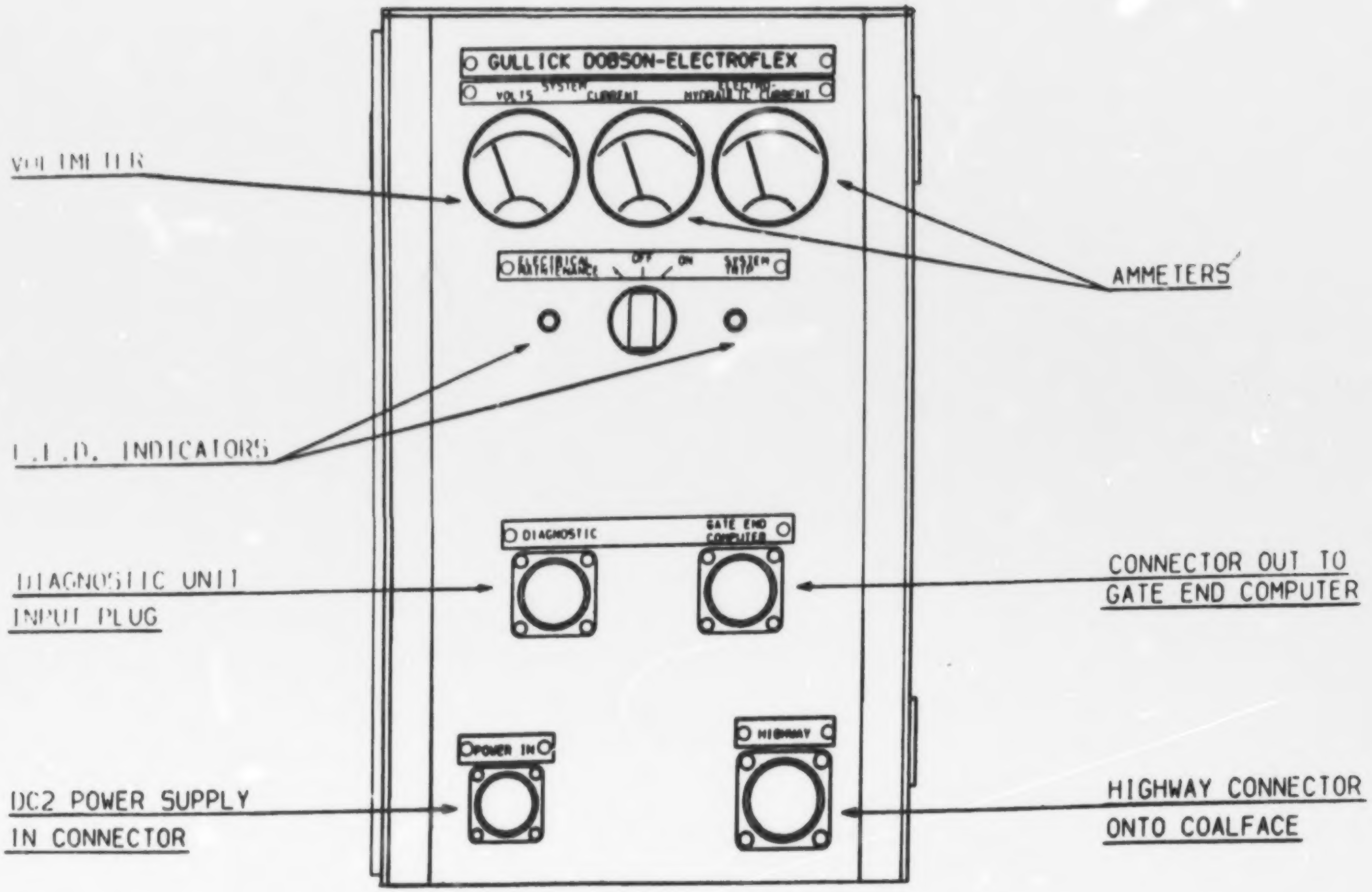

GULLICK DOBSON-ELECTROFLEX
VOLTS
SYSTEM CURRENT
ELECTRO-HYDRAULIC CURRENT
ELECTRICAL MAINTENANCE
OFF
ON
SYSTEM TRIP
DIAGNOSTIC
GATE END COMPUTER
POWER IN
HIGHWAY
VOLTMETER
AMMETERS
L.E.D. INDICATORS
DIAGNOSTIC UNIT INPUT PLUG
CONNECTOR OUT TO GATE END COMPUTER
DC2 POWER SUPPLY IN CONNECTOR
HIGHWAY CONNECTOR ONTO COALFACE

FIG. 3A

GATE END UNIT

The controls available can be 'local' as well as sequential. Local control can be carried out on one part of a coal face whilst sequential control is being carried out on another. Should a fault occur in the Gate End Computer, or should communications be broken, local control is still available.

3.2. ELECTROHYDRAULIC INTERFACE PACK

A typical EIP is shown in figure 5.

The pack houses the electrohydraulic interface valves, the pressure switches and the flow amplification valves necessary to make Electroflex work.

The number of valve elements is varied as the number of required functions varies. The maximum number of valves is envisaged as being six, giving control of lower and advance, set, AFC push, forepole extend, sprag extend and sprag park.

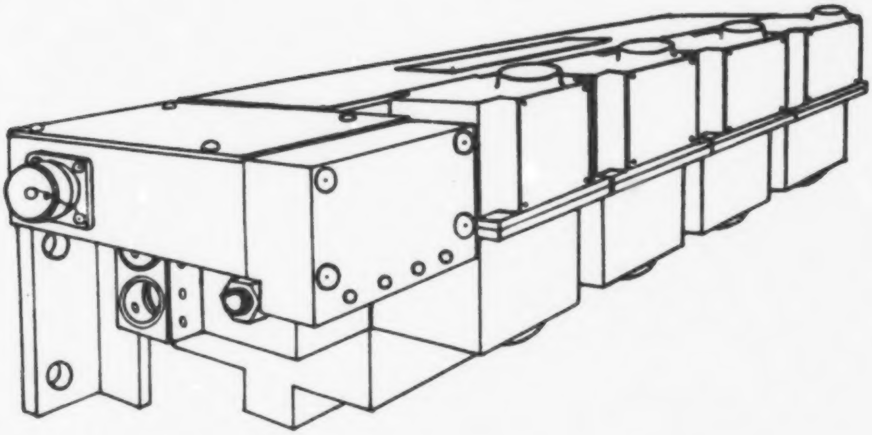


FIG 5 ELECTROHYDRAULIC INTERFACE PACK

4. OPERATION

4.1. GENERAL

The operations described are typical only. Any logical sequence of operations can be catered for provided that they can be determined beforehand. Electroflex will, to some extent, be user programmable in that an official will be able to alter certain parameters (e.g. the distance a sprag retracts in front of a machine).

Liaison with Gullick Dobson before installation will ensure that the requirements of a particular face working pattern are accommodated.

It is possible to perform 'local' operations in one part of the face while performing sequential operations in a different part.

Gullick Dobson have now developed a new solenoid valve with similar hydraulic parameters to the previous ones, but which takes a much lower current, typically 10 mA. This has enabled a new outlook to be formed on the operational flexibility of a system. As we are now able to operate up to 20 solenoid valves at any one time, we have the capability to pass signals much faster, we can have local controls which will not need to wait for solenoid power to become available and we can have multiple operation of such operations as forepoles and sprags.

All support operations have the following:

Pre-start warning previous to, and during, supports advancing.
Pre-start warning prior to conveyor advance operation.
Pre-start warning prior to forepole extend operation.
Pre-start warning prior to sprag operations.

All push button operations on Electroflex units have L.E.D. indication for command acceptance. The system has flexibility for bi-directional control.

4.2. ON COALFACE LOCAL OPERATION

As a separate operation to sequential control, supports may be operated in a local mode. This may be carried out at other parts of the coal face whilst auto sequential control is in operation, or it could substitute for auto control operations if so desired.

A.F.C. ADVANCE

When a support 'A.F.C. Advance' switch is operated in the 'local' position, the system will pressurise the A.F.C. pushing ram 'in support'. A.F.C. pushing will then continue until electrical feedback from the ram indicates that the ram is fully pushed out. For effective pushing, several supports will need to be locally 'A.F.C. Advanced' progressively along the coalface. Each pushing operation will not be on the 'dead man's handle' principle.

FOREPOLE EXTEND

When the 'Forepole Extend' switch is operated, the forepole on the same support will extend. The electrohydraulic initiator valve will remain energised for a number of seconds to ensure that the forepole is fully extended. The Forepole Extend switch is not operated on the 'dead man's handle' principle.

ADJACENT ADVANCE

When either the L.H. Adjacent Advance or R.H. Adjacent Advance switch is operated it will activate the appropriate support. The support will go through a hydraulic sequence of lower, advance and leg set. Should the support need to be reset part way, during the stroke, the 'Legs Raise' mode is selected and the support will set to the roof at that point. Leg setting pressure is confirmed to the electronic system by pressure switches. This also indicates that the operation is complete. Adjacent support advance will be on the 'dead man's handle' principle.

4.3. SEQUENTIAL OPERATIONS

To demonstrate the versatility of programming available using the Gullick Dobson Electroflex system, three different sequences are shown below. It must be emphasised at this stage that these are not the only possible methods of working and that any logical cycle of events can be controlled.

4.3.1. ON FACE PUSH BUTTON (1)

This sequence is shown in figure 6.

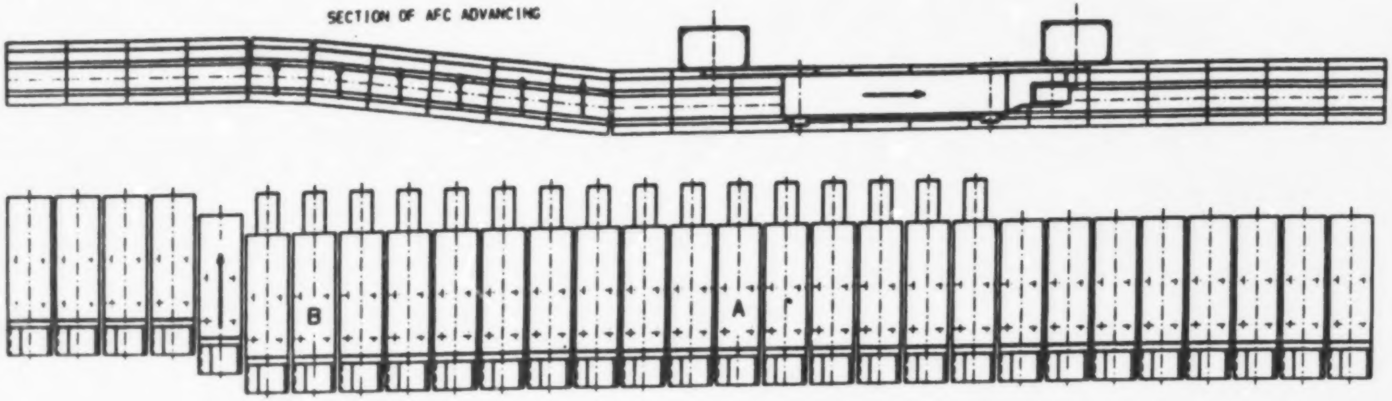
The coal face is depicted as having forepoles, but no sprags. The support operation is independant of the shearer operation and it is assumed that two operators will perform the support sequence.

Operator 'A' follows close to the machine. This operator presses the button for 'Forepole Extend'. As depicted on figure 6, the forepoles would extend some distance in front of him, just behind the leading drum. It is just as likely that he may wish the forepoles to extend behind the trailing drum. This distance from operator to operation is known as the headway. The headway can be varied at the Gate End Computer and can be positive or negative, to suit local conditions.

Should the operator fail to push the 'Forepole Extend' button for two or three supports, when he next pushes it, the forepole at the next designated headway will extend, together with those which have previously been missed.

Operator 'A' also presses the 'AFC Advance' button. The AFC will push over a headway distance behind him. Should he have failed to push this button for several supports, the support ram at the designated headway will push together with others which have been missed. However, for 'AFC Advance' it may not be desirable to have every ram pushing. The Electroflex system will, therefore, put 1 in 1, 1 in 2, 1 in 3 etc. on to push. The pitch of the pusher rams will be changeable at the Gate End Computer, as will the headway.

The Gullick Dobson 'Electroflex' electrohydraulic control system.



SEQUENCE OF OPERATIONS

1 Operator 'A' presses the 'Forepole Advance' button, which extends and sets the forepole behind either the leading drum or the trailing drum as required.

2 Operator 'A' presses the 'AFC Advance' button, which extends the push ram behind the machine.
The headway distance between the operator and the pushing can be varied at the face end.

3. Operator 'B' presses the 'Advance Enable' button, which sequentially clears the supports for advance. The 'Sequence Start' button need be pressed only once for each uninterrupted sequence. Supports will not advance sequentially into the snake area.

LOCAL OPERATIONS

Each support has local push button controls which can be used simultaneously with sequential operations elsewhere in the face as follows:-

Local conveyor push
Bi-Di adjacent advance of individual supports

Bi-Di adjacent reset of individual supports at any point during support advance.

Local extension bar set

TITLE FIG 6 - ON FACE PUSH BUTTON CONTROL - (1)

Operator 'B' is in control of supports advancing. He presses 'Support Enable' on every support. This clears a support to advance when certain parameters have been checked. These parameters include ensuring that the neighbour on either side is set to the roof and that the support is clear of the snake area.

At one point on each run, operator 'B' presses 'Sequence Start' which will advance supports in sequence until prevented from doing so - either the checks are not satisfied, or the support has not been cleared.

4.3.2. ON FACE PUSH BUTTON (2)

This sequence is shown on fig. 7.

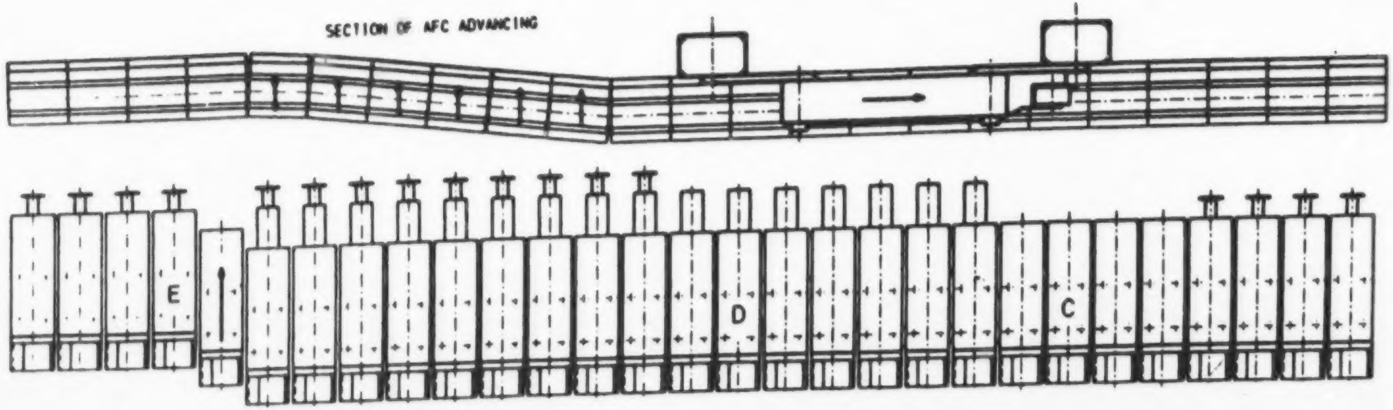
This coalface is depicted as having both forepoles and sprags. The operation of the supports is dependant upon the integration of the shearer operators into the process.

Operator 'C' is the leading drum operator. It is accepted that his position is not necessarily fixed in relation to the shearer. Electroflex makes the necessary adjustments. The function of operator 'C' is to retract the sprags and extend the forepoles. As he presses the 'Sprag Retract' button, the next sprag not previously retracted will retract. If he presses the same button on the same support, a second sprag would retract. The number of sprags retracted from any station is limited only by a maximum headway, programmed at the Gate End Computer.

Similarly, operator 'C' presses the 'Forepoling Extend' button, and the next forepole not previously extended will extend. The forepoles will extend only as close as a programmable headway allows.

Operator 'D' is the trailing drum operator. [illegible] is in charge of extending the sprags and pushing the AFC. As he presses the 'Sprag Extend' button, the next sprag not previously extended will extend, up to a programmable headway distance. As he presses the 'A.F.C. Advance' button, the next support ram will go on to push, up to a programmable maximum. The transfer of these movements continues up the face in the same manner as previously described.

The Gullick Dobson 'Electroflex' electrohydraulic control system.



SEQUENCE OF OPERATIONS

1. Operator 'C' presses the 'Sprag Retract' button, which retracts the next sprag in sequence.
2. Operator 'C' presses the 'Forepole Extend' button, which extends the next forepole in sequence.
3. Operator 'D' presses the 'Sprag Extend' button, which extends the next sprag in sequence.
4. Operator 'D' presses the 'AFC Advance' button, which puts the next ram in sequence onto push.
5. Operator 'E' presses the 'Advance Enable' button, which clears the next suppprt in sequence for advance, provided it's neighbour has set to the roof. Sprags are automatically reset after the support has set.

LOCAL OPERATIONS

Each support has local push button controls which can be used simultaneously with sequential operations elsewhere in the face as follows:-

Local conveyor push
Bi-Di adjacent advance of individual supports

BI-DI adjacent reset of individual supports at any point during support advance.

Local extension bar set'
Local sprag set
Local sprag retract

Operator 'E' is in charge of support advance. He follows behind the advancing supports. He presses the 'Support Enable' button which clears the next support for advance, provided that the parameters mentioned in 4.3.1. are checked. The distance from the operator to the enabled support has a programmable maximum.

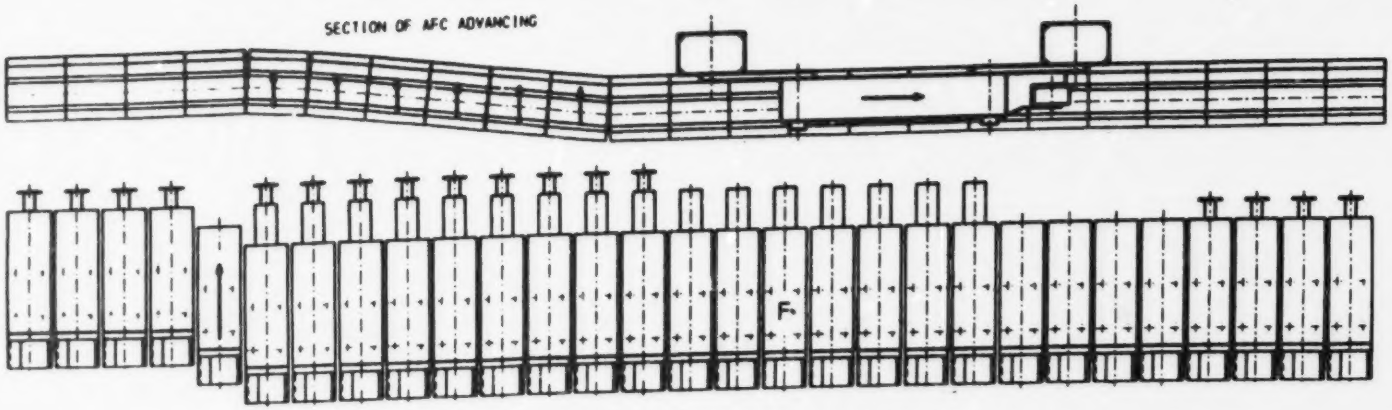
On completion of support set, the sprag automatically resets to the coal face.

4.3.3. 'MACHINE' INITIATION

All support operations can be linked to machine position. The only requirement additional to the standard Electroflex equipment is for a reliable shearer position indication to be available. The reliability of this link is not yet proven. However, the Gullick Dobson Electroflex can obviate the requirement for this link. This is demonstrated in figure 8, which shows a face with sprags and forepoles.

Operator 'F' travels in a fixed position relative to the shearer. He may be, in fact, the shearer operator. At programmable headway distances the sprag will retract, forepoles extend, sprags set, AFC advance, supports advance and sprags reset.

The Gullick Dobson 'Electroflex' electrohydraulic control system.



SEQUENCE OF OPERATIONS

Operator 'F' presses the 'Support Enable' button on each support as he travels the face. He remains in a fixed relationship with the shearer. The Electroflex system interprets his progress along the face as the machine position. From this data, all support operations take place i.e. sprags are retracted in front of the shearer, forepoles extended behind leading drum, sprags extended behind trailing drum, AFC advanced behind shearer, supports advanced behind snake and sprags reset when supports have been set.

LOCAL OPERATIONS

Each support has local push button controls which can be used simultaneously with sequential operations elsewhere in the face as follows:-

Local conveyor push
Bi-Di adjacent advance of individual supports

Bi-Di adjacent reset of individual supports at any point during support advance.

Local extension bar set
Local sprag set
Local sprag retract

TITLE FIG 8 - 'MACHINE' INITIATION

APPENDIX B

AUTOMATIC STEERING SYSTEMS
MIDAS
DIAM
PATHFINDER

Anderson
Strathclyde PLC

MIDAS

Machine Information Display and Automation System

Anderson Strathclyde PLC

AUTOMATION OF COAL FACE SYSTEMS USING MIDAS

Introduction

Since the 1960's automation of longwall shearers has mainly been concerned with achieving a successful automatic vertical guidance or automatic steering system. The objectives of such a system are:

1. To mine the best section of the coal seam consistently
2. Produce a cleaner more profitable product
3. Maximise the extraction
4. Improve strata control and hence improve safety
5. Increase output

The benefits to be gained from the successful and consistent use of an automatic steering system on a shearer are considerable in terms of financial returns and safer working places. The extra finance has been shown to be from an increase in quantity and market value of the product as the more consistent face conditions usually result in an increase in output and the quality is improved because of less ash content. Coal face hazards are reduced by improved chock beam to roof contact when the cut roof is controlled between successive cuts as it is under automatic steering control.

The Mining Research and Development Establishment (MRDE) initiated a program to develop automatic vertical steering system for longwall faces in 1976. This program produced a prototype trials system called System 70000*. It was a microprocessor based system designed to survive in the environment usually associated with longwall shearers. It had to cope with temperature variation, shock, vibration, dust and dirt, very noisy power supplies and constant switching on and off. New transducers were developed and the system was also required to be intrinsically safe and operationally approved.

Ten machines, six of which were Anderson Strathclyde shearers, were installed equipped with System 70000. Due to the success of these installations the decision was taken to develop a commercial version which would replace System 70000 and facilitate exploitation. MRDE, in conjunction with S.E.I. and ourselves have now produced MIDAS (Machine Information Display and Automation System). It incorporates many improvements over System 70000 and has certain distinct advantages.

*NOTE: System 70000 was itself based on the experience gained with the earlier analogue, 326B, steering system.

1. Cost:

   Rationalisation of the functions of the underground and surface equipment has allowed the cost of MIDAS to be reduced in comparison to that of System 70000.

2. User Friendly:

   The use of the MIDAS equipment has been organised to be more easily understood by the user having little experience of the equipment.

3. Reduced and Simplified Maintenance:

   Ease and speed of maintenance has been a major design feature of MIDAS.

4. Universally Acceptable to all Shearers:

   Facilities are provided to allow MIDAS to be easily and quickly set up to cater for various machine specifications and methods of working.

5. Improved Surface Monitoring:

   Formats have been improved on the surface equipment and MIDAS may also be integrated with the National Coal Board's MINOS (MINe Operating System) operating equipment.

6. Manufacturer supportable:

   Anderson Strathclyde PLC have been closely involved at all development and design stages.

The primary objective of MIDAS is to control automatically the amount of roof coal left on the face while limiting both the step in the roof and the angle of the shearer in the line of face advance to values consistent with good mining practice. In addition the system provides facilities for monitoring the condition of the shearer via transducers for such parameters as pressure, temperature, oil level, oil flow and oil condition and for transmitting the data obtained from these condition transducers and the control transducers to a surface computer for management information purposes and trend analysis. A typical MIDAS system in shown in Fig. 1.

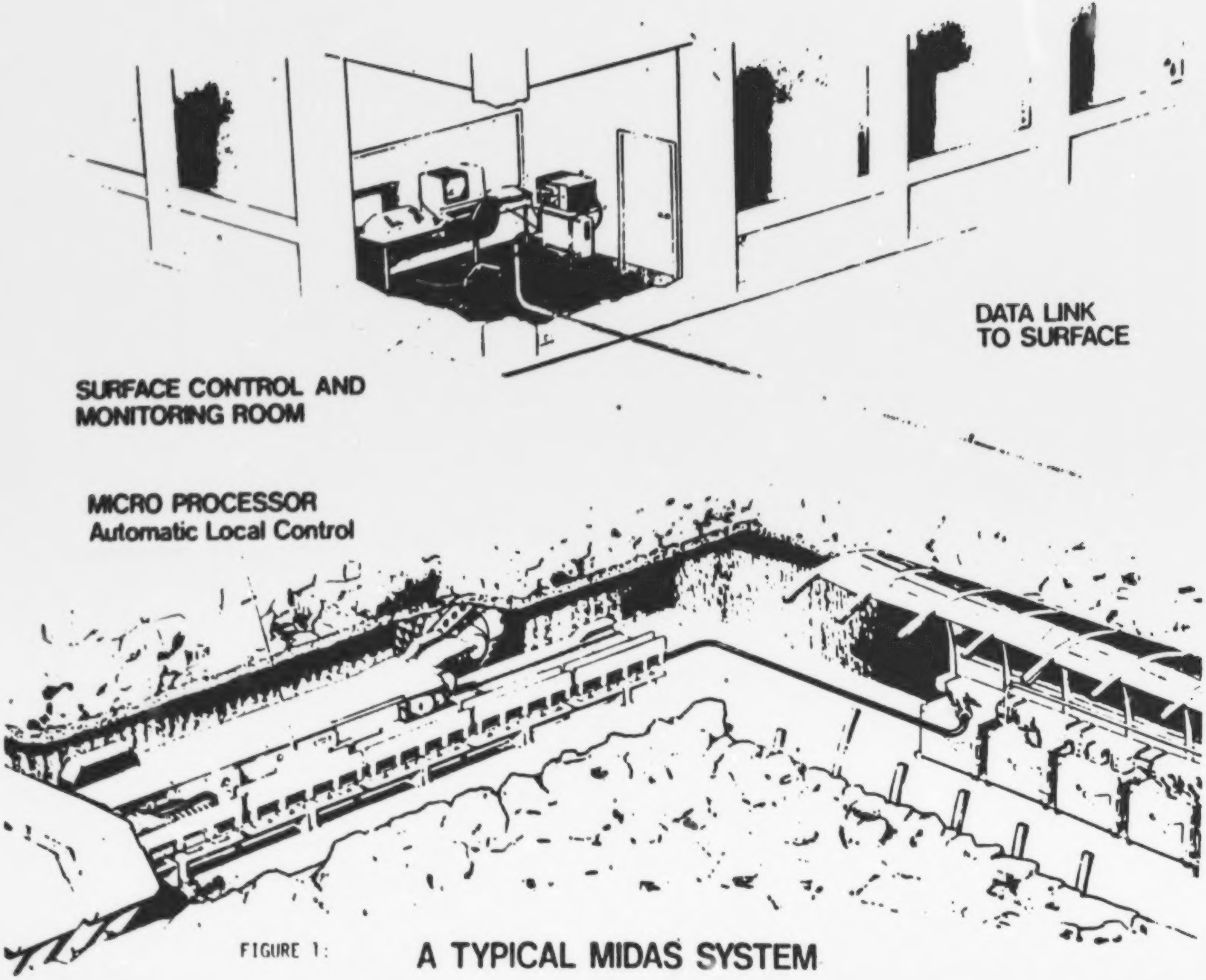

DATA LINK
TO SURFACE
SURFACE CONTROL AND
MONITORING ROOM
MICRO PROCESSOR
Automatic Local Control

FIGURE 1: A TYPICAL MIDAS SYSTEM

Anderson
Strathclyde PLC

Equipment required for MIDAS

1. Purpose built additional machine section to house equipment associated with the system (Fig. 2 Control Section Layout).

   (a) MIDAS Control Unit: The brain of the system, a machine mounted micro-computer which has been specifically designed for the task of automaticaly guiding the shearer. The unit receives information about the surrounding environment from the transducers and sensors mounted on the machine and makes decisions on the type of steering action required to maintain optimum mining conditions. Once these decisions have been made, control demands are issued to initiate ranging arm movements.

   The unit measures 330mm x 300mm x 255mm, has a liquid crystal display of 4 lines by 32 characters and it contains three RCA 1802 CPU's (Central Processing Units) each with 32K of RAM (Random Access Memory) and 32K of ROM (Read Only Memory).

   (b) Personality Unit: Allows for the wide variety of different mining conditions and machine types which exist throughout the country, to be dealt with by one standard MIDAS control unit. Variations particular to a face such as ranging arm length, desired roof coal thickness, haulage type, etc are entered into the MIDAS unit memory via the 32 rotary switches on the front panel of the unit. To prevent access by unauthorised personnel, entry to the switch panel is by a security key. Opening the front door during normal operation causes the system to return to commissioning mode, which is used during face installation.

   The unit measures 300mm x 100mm x 100mm and contains one RCA 1802 CPU.

   (c) Power Supply Unit: This unit produces three segregated supplies designated IS1, IS2 and IS3. IS1 produces 10 volts stabilised at 500mA and is used to power the MIDAS control and personality units and all transducers with the exception of the Machine Movement and Direction Detector (MMADD). IS2 produces 10 volts stabilised at 250mA and is used to power the machine mounted data transmission system. The IS3 power supply produces 5 volts at 250mA and powers the Machine Movement and Direction Detector.

   The unit measures 200mm x 160mm x 123mm.

   (d) Multiplexer: The multiplexer retransmits data from the MIDAS control unit along the trailing cable while maintaining IS segregation. In doing this the data rate is slowed from the high rate at which MIDAS transmits data to the slower rate required by the transmission line to the surface. Existing installations require an additional multiplexer on the gate end to extract the data from the pilot circuit.

   The multiplexer measures 280mm x 185mm x 60mm.

(e) Associated electro-hydraulic equipment necessary to carry out the functions of the MIDAS system.

2. Roof Follower: This is a pivoted mechanical arm which is raised and held against the previously cut roof alongside the cutting drum by hydraulic pressure. A transducer is mounted at the pivot point of the arm and provides an electrical signal proportional to the vertical displacement of the roof follower arm. The complete mechanical arrangement is fixed to the top of the ranging arm.

   The electrical signal produced provides the MIDAS unit with the reference around which all the steering demands are based i.e. if the roof coal thickness sensor and tilt transducer indicate that the boom requires raising by 15mm, then this movement is made relative to the roof follower position. All steps in the roof or floor are normally limited to a maximum of +/- 40mm to maintain optimum mining conditions.

3. Roof Coal Thickness: The transducer employed to measure the thickness of roof coal is the type 801 Natural Radiation Sensor which has been in use for some years in coal thickness indication systems.

   It has been found that most roof shales in coalmining contain a measurable amount of radioactivity. Coal, due to its density, will act as an absorber of the radiation from the overlying shale. The degree of absorption will increase as the thickness of coal increases thus providing a method to measure the amount of roof coal being left during shearing.

4. Tilt Transducers: There are two tilt transducers in the system to measure;

   (a) Face Advance Tilt (FAT) angle i.e. the angle of the machine, relative to the seam inclination, in the direction of face advance; and

   (b) Along Face Tilt (AFT) angle i.e. the angle of the seam inclination along the face (used only for monitoring face contour variations).

   Both transducers are contained in steel boxes bolted to the machine underframe.

5. Machine Movement and Direction Detector (MMADD): This transducer detects movement of the shearer in each direction. It provides information to allow the machine position, relative to the maingate centre-line, along the face to be monitored. The MMADD is a cylindrical steel unit which can be sited in the position where it is most convenient to pick up the machine drive.

6. End of Face Detector: An erroneous along face position can be indicated for such reasons as a broken machine haulage chain, cummulative errors as successive shears are taken or if the MMADD unit is turned without the machine being moved. To counteract such happenings the End of Face Detector is included in the system. It is in two parts:

   (a) a stainless steel casting, housing a permanent magnet bolted to the conveyor pan furnishings; and

   (b) a magnetically-operated switch, housed on the machine underframe in such a manner as to pass within 40mm of the conveyor-mounted magnet as the machine goes by.

   As the magnet is passed, the machine mounted switch is operated, signalling to the MIDAS unit that the machine is now at a known position. Any errors in the MMADD count are then corrected.

7. Haulage Direction Sensor: This unit is operated by the haulage direction switch and indicates the direction of machine travel, right or left, to the MIDAS unit.

8. Ranging Arm Height Transducer: This transducer is identical to that used on the roof follower. It is driven by the ranging arm trunnion shaft and measures the angle of the ranging arm relative to the machine body.

   As the shearer passes on its roof cut with the roof follower held against the roof, the ranging arm angles are taken at intervals and committed to MIDAS memory. On the return floor cut these readings are used by the MIDAS unit, utilising simple trigonometry, to control the ranging arm movement downwards, the roof follower being powered down. The floor cut is therefore an exact copy of the roof cut.

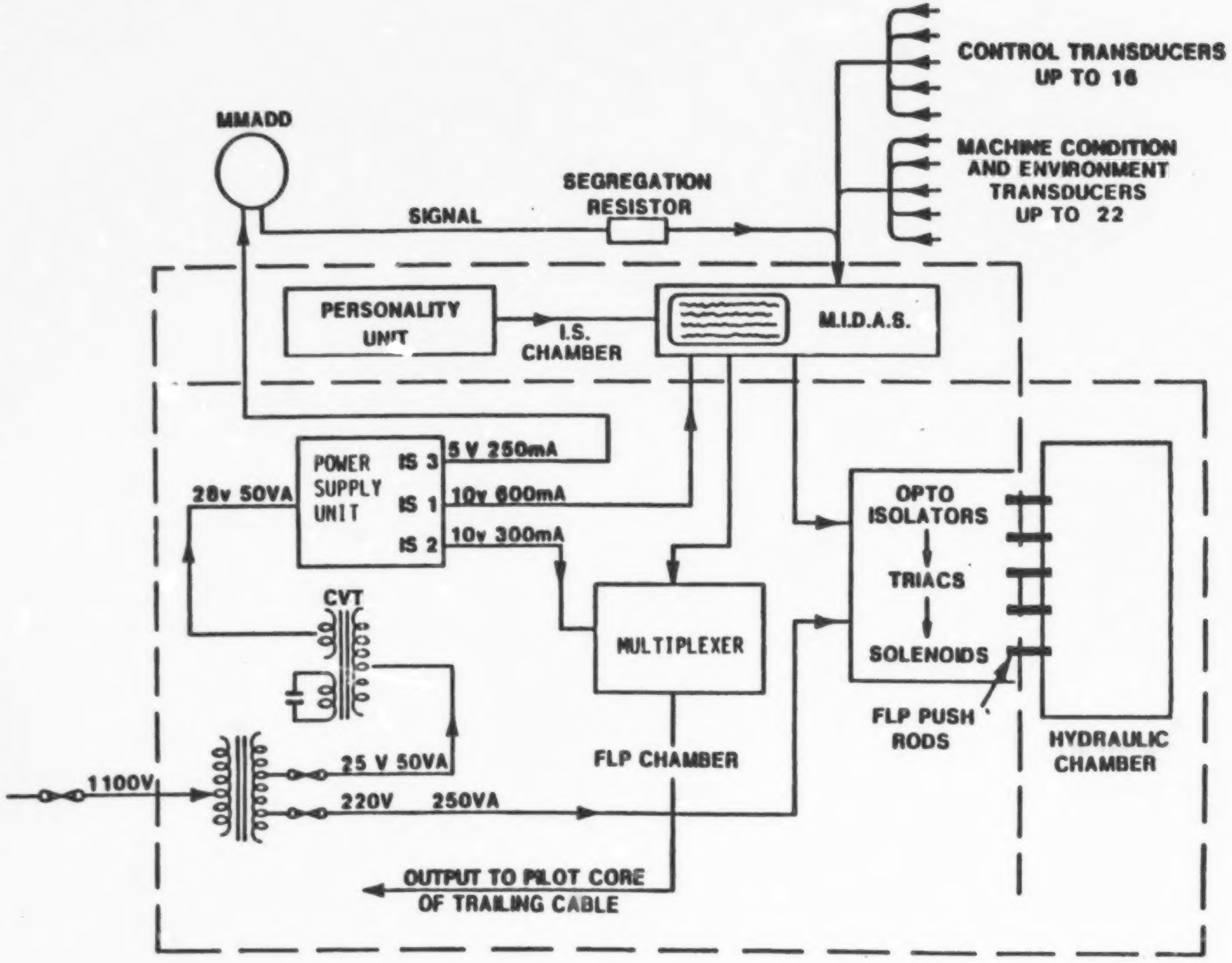
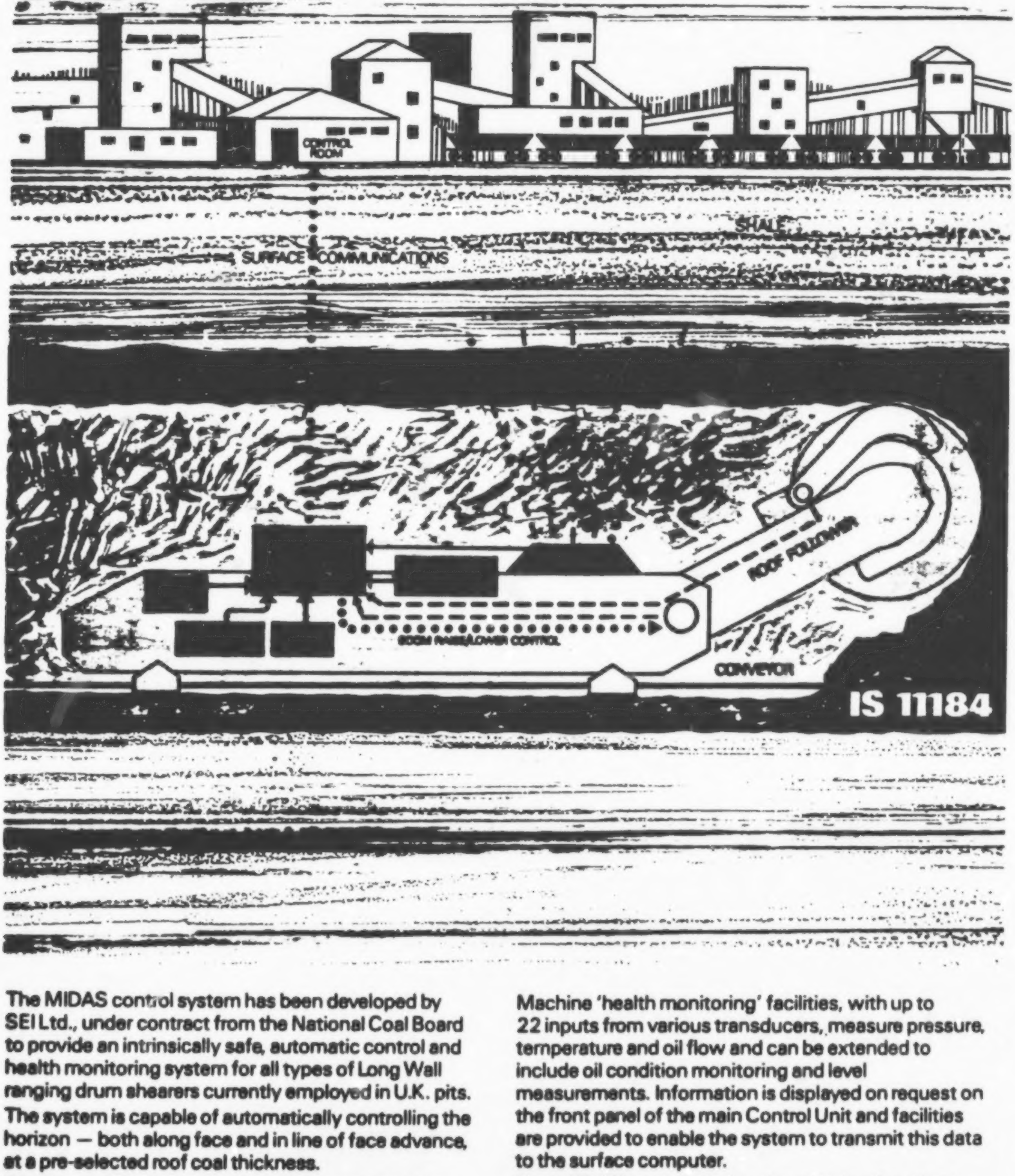

CONTROL TRANSDUCERS
UP TO 16
MACHINE CONDITION
AND ENVIRONMENT
TRANSDUCERS
UP TO 22
MMADD
SEGREGATION
RESISTOR
SIGNAL
PERSONALITY
UNIT
I.S.
CHAMBER
M.I.D.A.S.
POWER
SUPPLY
UNIT
IS 3
IS 1
IS 2
5 V 250mA
10v 600mA
10v 300mA
28v 50VA
CVT
OPTO
ISOLATORS
TRIACS
SOLENOIDS
MULTIPLEXER
FLP PUSH
RODS
HYDRAULIC
CHAMBER
1100V
25 V 50VA
220V
250VA
FLP CHAMBER
OUTPUT TO PILOT CORE
OF TRAILING CABLE

FIG 2 CONTROL SECTION LAYOUT

SEI midas (machine information display and automation system)



The MIDAS control system has been developed by SEI Ltd., under contract from the National Coal Board to provide an intrinsically safe, automatic control and health monitoring system for all types of Long Wall ranging drum shearers currently employed in U.K. pits.

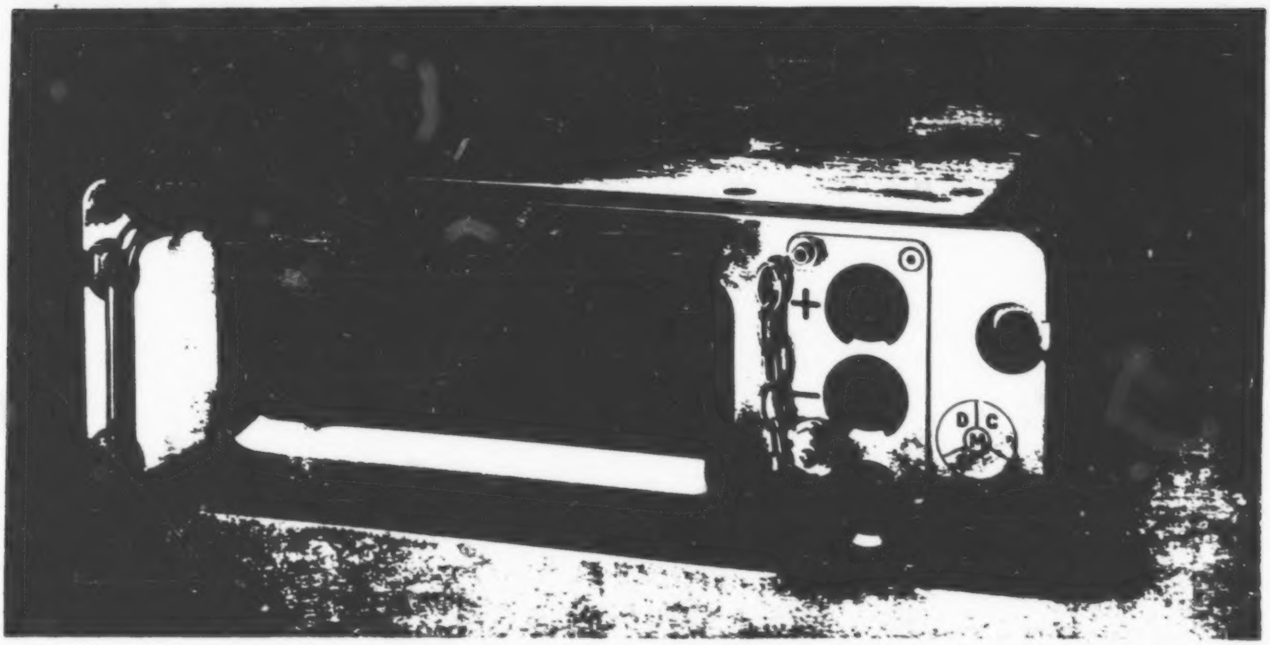
The system is capable of automatically controlling the horizon — both along face and in line of face advance, at a pre-selected roof coal thickness.

The Personality Unit, which may be programmed on the face, can accommodate a wide range of machine and face parameters including face lengths, seam angle, drum diameter, required extraction and mining methods, etc.

Machine 'health monitoring' facilities, with up to 22 inputs from various transducers, measure pressure, temperature and oil flow and can be extended to include oil condition monitoring and level measurements. Information is displayed on request on the front panel of the main Control Unit and facilities are provided to enable the system to transmit this data to the surface computer.

Up to 37 different control and monitoring functions may be accommodated by the MIDAS system, and the equipment is sufficiently flexible to enable it to be used in conjuction with other types of machines such as Roadheaders.

control unit MRD 90001



The Control Unit offers a wide range of control facilities e.g. Single Ended Ranging Drum Shearers operating on single pass or two pass extraction.

The unit interrogates all the control and health monitoring transducers and provides a control signal to the shearer to enable a stable horizon to be maintained.

Information received from the transducers is displayed on the front panel, giving operators clear and concise details. Facilities are available to transmit this data to the surface.

personality unit MRD 90003

The Personality Unit permits the particular features of a given machine and face to be accommodated by setting up the 32 hexadecimal switches to enable information to be stored on such parameters as drum diameter, face length, boom angle range, mining method etc.

Provision is made to ensure that these parameters can only be changed by authorised personnel; access to the switch panel being controlled by a security key. Three serial communication links are also available on the unit which permits the MIDAS system to transmit and receive data from other equipment on the coal cutting machine.

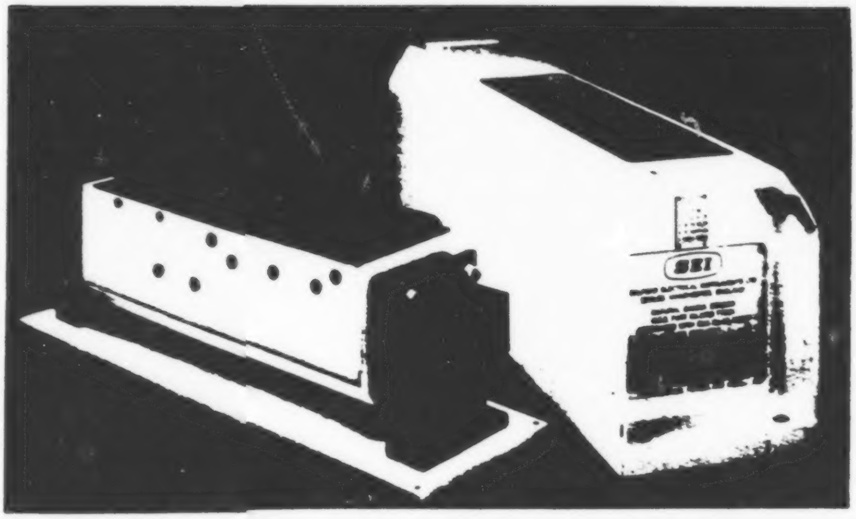
SEI
TRICAL INSTRUMENTS LTD.
OOD, LANCASHIRE.
NTROL SYSTEM 90000
CLASS.I BS 1259:1958
ALITY UNIT
90003

type 801 natural gamma probe

MRD 77801, IS1934

This probe is capable of measuring coal thickness up to 50cm over a wide range of shale activities (approx. 10-40 picocuries/gm) and is capable of accommodating machine speeds of upto 20ft/min.

Digital and analogue outputs are provided for control or indication purposes. Power supply requirements are 10V DC 350mW approximately. The unit has been designed to withstand the rugged conditions encountered when mounted on a coal cutting machine, in a mining environment.



machine movement and direction detector

MRD 91754, MRD 91640

This transducer provides the system with the information required by the control unit to compute the machines position, direction and speed.

This information is a fundamental requirement for automatic control of the machine and consequently dual sensors are employed, a signal being provided when either sensor fails.

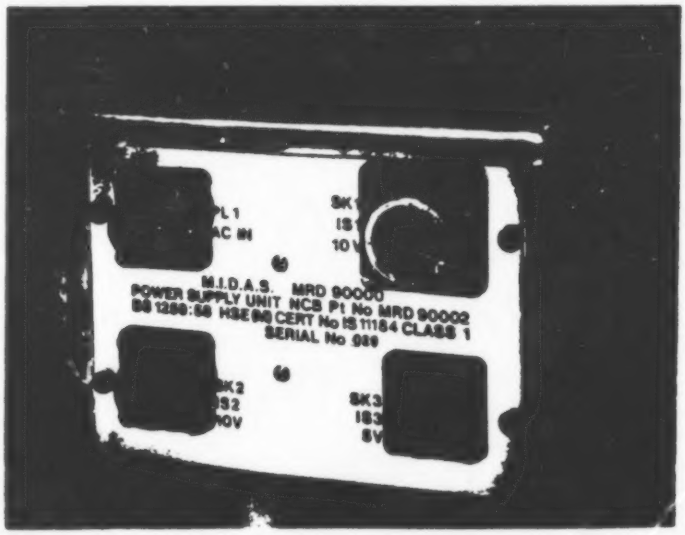
The unit is powered by IS3 and the output signals are buffered in the main junction box before being fed to the MIDAS control unit.

power supply MRD 90002

Three segregated supplies are available designated IS1 IS2 and IS3.

IS1 produces 10 volts stabilised at 500mA and is used to power the MIDAS control and personality units and all transducers with the exception of the Machine Movement and Direction Detector. IS2 produces 10 volts stabilised at 250mA and is used to power the machine mounted data transmission system. The IS3 power supply produces 5 volts at 250mA and powers the Machine Movement and Direction Detector.

A 'Computer Run' signal is also provided to control the 'power up' and 'power down' of all microprocessors used in the system.



test equipment

A range of test equipment is available which provides rapid fault diagnosis of cables and equipment.

The control interface monitor — MRD 93909, permits the intrinsically safe interface to the machines hydraulic system to be exercised independently of the MIDAS control unit.

The transducer simulator units simulate both analogue and digital transducers at fixed levels and intervals. Signals can be injected at either end of the transducer coupling cable.

A unit is available, MRD 90241, which simulates all the transducers that can be interrogated by the MIDAS control unit. It may be connected into the MIDAS unit directly or via the junction box cables. A similar unit, MRD 90251 is also avialable which couples to the junction box output connectors.

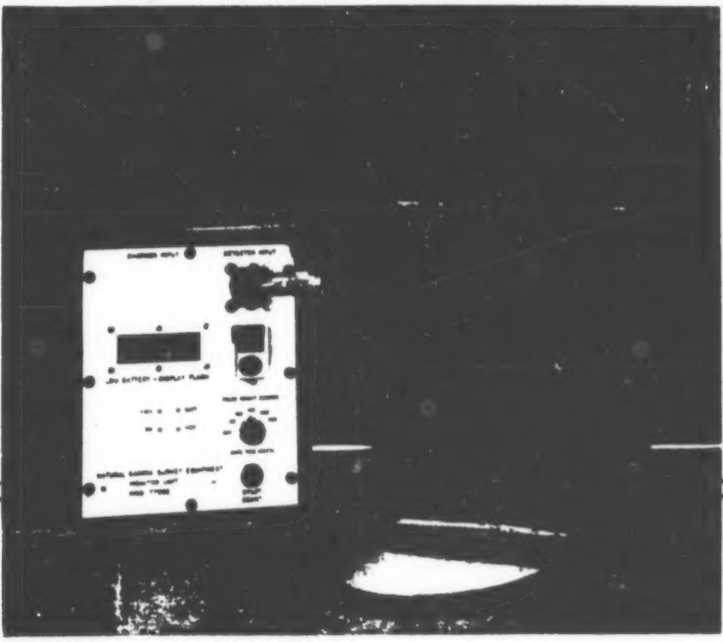
---

survey equipment

MRD 77900, IS11014

This equipment is designed to permit potential sites to be surveyed to determine their suitability for the use of Natural Gamma equipment.

The units which are portable, comprise a small shielded scintillation counter and a microprocessor based monitor. Both units are contained within leather carrying cases with shoulder straps. The equipment is designed for minimum power consumption and is capable of continuous use for at least 8 hours.



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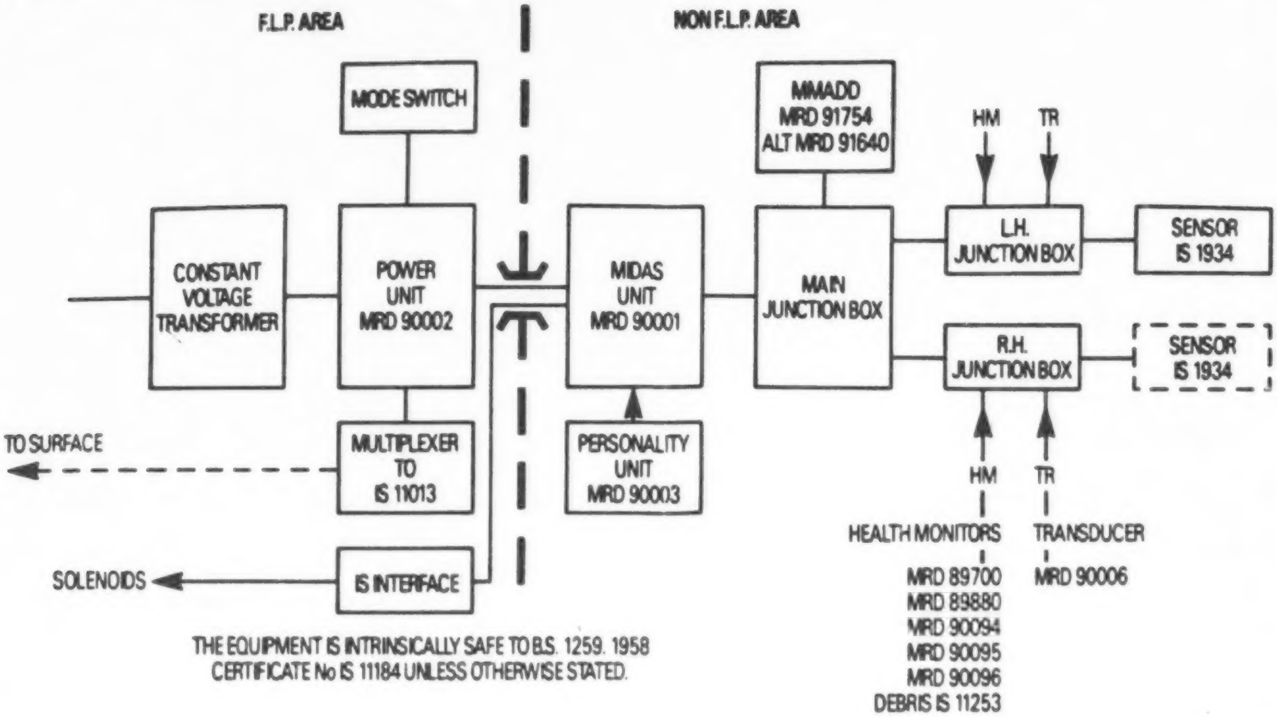
end of face detector

MRD 90050

This transducer is mounted on the underframe of the shearer and is used in conjunction with a magnet assembly mounted in a suitable position on the conveyor spill plates.

typical block diagram


F.L.P. AREA
NON F.L.P. AREA
MODE SWITCH
MMADD
MRD 91754
ALT MRD 91640
HM
TR
CONSTANT VOLTAGE TRANSFORMER
POWER UNIT MRD 90002
MIDAS UNIT MRD 90001
MAIN JUNCTION BOX
L.H. JUNCTION BOX
SENSOR IS 1934
R.H. JUNCTION BOX
SENSOR IS 1934
TO SURFACE
MULTIPLEXER TO IS 11013
PERSONALITY UNIT MRD 90003
HM
TR
HEALTH MONITORS
MRD 89700
MRD 89880
MRD 90094
MRD 90095
MRD 90096
DEBRIS IS 11253
TRANSDUCER
MRD 90006
SOLENOIDS
IS INTERFACE

THE EQUIPMENT IS INTRINSICALLY SAFE TO B.S. 1259. 1958
CERTIFICATE No IS 11184 UNLESS OTHERWISE STATED.

dimensions and mounting details

All Units unless specified otherwise to Intrinsically Safe Cert. No. IS 11184 Class 1.

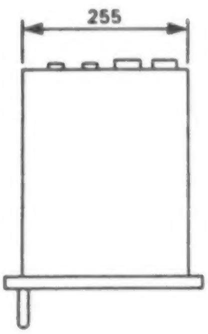
Dimensions in millimetres

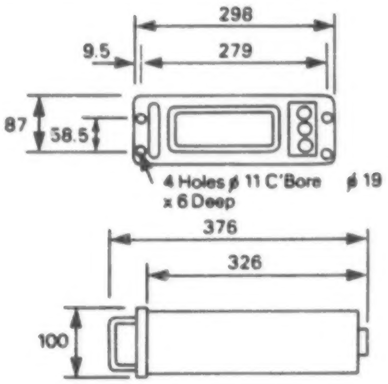
midas control unit

MRD 90001

Weight 12.5kgs

IS Cert No. 11184 Class 1.



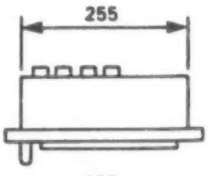

298
9.5
279
87
58.5
4 Holes ø 11 C'Bore ø 19
x 6 Deep
376
326
100

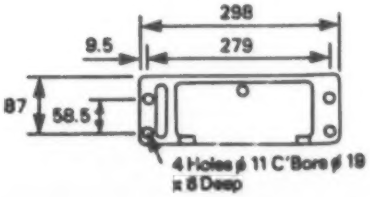
personality unit

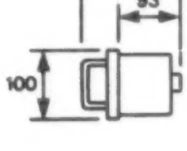
MRD 90003

Weight 5 kgs

IS Cert No. 11184 Class 1.




298
9.5
279
87
58.5
4 Holes ø 11 C'Bore ø 19
x 6 Deep



dimensions and mounting details

All Units unless specified otherwise to Intrinsically Safe Cert. No. IS 11184 Class 1.

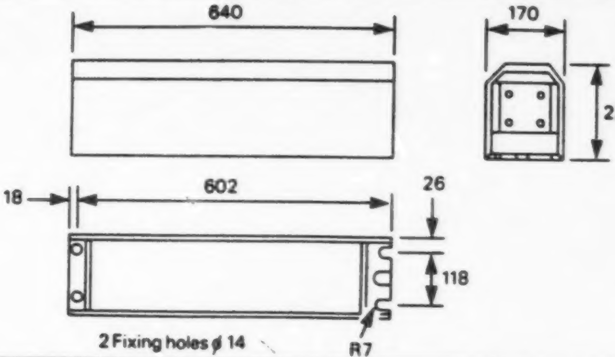
Dimensions in millimetres

natural gamma probe

MRD 77801

Weight 52kgs

IS Cert No. 1934/2 Class 1.


640
170
220
18
602
26
118
2 Fixing holes ϕ 14
R7

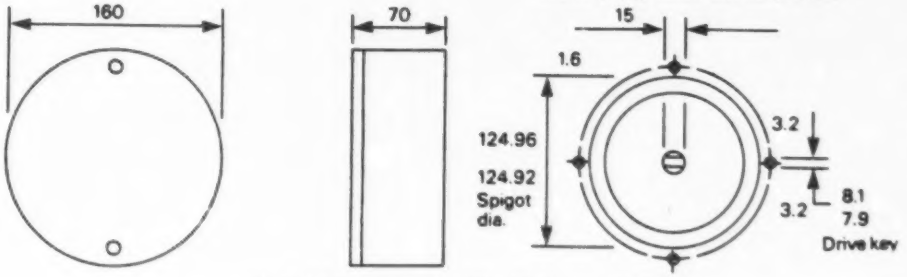
machine movement and direction detector

MRD 91754,
MRD 91640

Weight 5.5kgs

IS Cert No. 11184 Class 1.

View with MMADD unit removed showing spigot dia & drive key details.


160
70
15
1.6
124.96
124.92
Spigot
dia.
3.2
3.2
8.1
7.9
Drive key

4 holes ϕ 6.8 x 20 deep tap M8 x 15 deep on a 140 P.C.D. to be within 0.5 of true position T.I.R. datum spigot

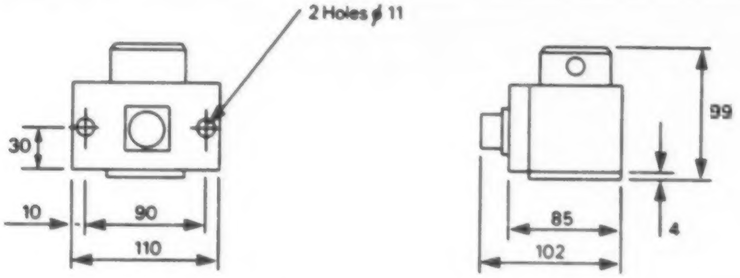
Note: Drive key must be central to spigot dia within +0.10

end of face detector

MRD 90050

Weight 2 kgs

IS Cert No. 11184 Class 1.

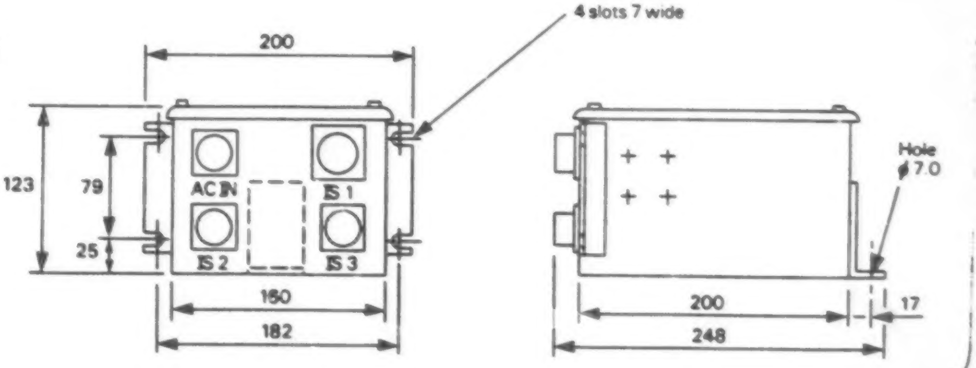

2 Holes ϕ 11
30
10
90
110
99
4
85
102

power supply unit

MRD 90002

Weight 5 kgs

IS Cert No. 11184 Class 1.


4 slots 7 wide
200
123
79
25
AC IN
IS 1
IS 2
IS 3
160
182
Hole
ϕ 7.0
200
17
248

SEI

Anderson
Strathclyde PLC

Condition Monitoring with MIDAS

Condition Monitoring is a method of implementing Condition Based Maintenance, which has superseded Planned Preventative Maintenance as a method of keeping mining equipment working with minimum downtime.

The aim of Condition Based Maintenance is to detect a slow deterioration in machine performance and condition long before catastrophic failure occurs. Clearly this must be done while the machinery is working, i.e. during normal shifts, since monitoring machine performance must be done while it is active. This involves monitoring various aspects of the machine's condition. Most of our shearers are hydraulically hauled, and so most of the monitored parameters are hydraulic, the basic ones being oil levels, temperatures, pressures and flowrates.

Although details vary between machine types, the majority of non-electrical faults are due to low oil levels because of leaks, and manifest themselves as noise or heat (due to lack of lubrication) or low pressures or flowrates. Rectification of such mechanical faults typically occupies more than 10% of the Machine Available Time - a typical 540 minute weekly delay due to power loader mechanical defects represents around 520 tonnes lost production and at a pit-head price of £50/tonne this represents a loss to the colliery of £26,000 per week. If even a fraction of this can be saved every week by conditon monitoring, then the cumulative saving over a year would be substantial.

The MIDAS computer can be used for performing condition monitoring. However, an elecronic computer cannot measure pressures, temperatures or flowrates directly, all it can do is some simple processing of electrical signals. The monitored parameters have to be converted into an electrical signal which the computer can deal with. This task is performed by the transducers. A transducer simply converts the parameter being monitored into a proportional electrical signal. By performing some simple arithmetic on this signal, the computer can scale it back into a pressure etc and display it as such on the computer screen.

It is technically possible to use the warning signal to stop the machine, but the prime function of the shearer is to cut coal, and anything which could prevent this is likely to be resisted by colliery management.

Condition Monitoring is not confined to oil pressures, temperatures and flowrates, and anything which can be converted into a suitable electrical signal can be monitored.

The NCB's development establishment at Bretby conducted a 'run to destruction' test on a gearbox while monitoring as many parameters on the box as they could. They were looking for information which could predict failure before it occurred. Two areas emerged as providing useful information - oil condition and vibration. Most of the others (temperature etc) merely confirmed that failure had indeed occurred.

Oil condition refers to the contamination of the oil by water and ferrous debris. Water can enter units in several ways, e.g. leaking oil coolers, condensation, strata water seeping in through damaged seals, etc. The effects of even small quantities of water in the oil can be serious. Not only does the water reduce the lubricating ability of the oil and encourage rusting during downtime, but water in suction lines can vapourise under the low pressures and cause cavitation of pumps. Emulsifying oils, which hold water, increase in viscosity when water is entrained. Although these oils may hold up to 8% water in a true emulsion, most manufacturers recommend changing the oil at around 2% water content, since water can have adverse effects on some of the additives in the oil which may tend to separate out. It is the additives in an oil which 'wear out', not the oil itself and so anything which affects these additives can have a serious effect on the properties of the oil.

Anderson Strathclyde have had a transducer developed which detects water in oil, and this is being evaluated in the Experimental Department at present.

Ferrous particles in the oil are an indication that wear is taking place. The size of the particles and rate of production can reveal a great deal about the health of the unit. Wear particles are a natural occurrence, even in perfectly healthy units, and can be detected long before catastrophic failure occurs.

Figs. 3 and 4 show typical wear particles. The time to take action is when this background debris gives way to failure debris, typically characterised by larger particle size and greater quantities. New units often exhibit a fairly large initial rate of debris generation due to bedding in, but this settles down to a constant rate 'plateau' throughout the working life of the unit.

Methods have been devised to detect ferrous particles on-line in machine units, and when the rate of generation of particles reaches a preset threshold then indication can be given so that an oil sample can be taken and sent for a full ferrographic analysis. This can often reveal the origin of the particles and differentiate between normal wear and wear preceeding failure by examination of the size and shape of the particles. In addition to this the loading conditions which caused the generation of the particles can often be assessed by their appearance. This analysis also extends to different failure modes in ball and roller bearings, and fatigue failure in gear teeth and shafts. An on-line debris monitoring transducer can act as an early warning system giving sufficient notice of impending trouble for remedial action to be taken. Such a device has been installed on the Silverwood MIDAS AB16 for test and evaluation.

In this machine, the gearhead gearbox lubricating pump has been used to pass the lubricating oil supply out of the gearbox via a modified pump housing and through the debris monitor. It is then filtered and returned to the gearbox through the pump housing where it is diverted back into the normal lubrication circuit.

The following functions will be monitored on the AM500 shearer (as shown in Fig 5).

RANGING ARM

The lubricating oil temperature in the arm will be measured at the epicyclic end.

GEARHEAD GEARBOX

The lubricating oil level, temperature and flowrate will be monitored in the gearhead gearbox to ensure that adequate lubrication of all bearings and gears is maintained. Where an oil cooler is fitted, the water flowrate through it will also be monitored.

POWER PACK

The hydraulic sump oil level and temperature and gear oil temperature will be monitored in the power pack. The haulage pressure, auxiliary pressure, priming pressure and suction vacuum will be monitored by transducers situated in a transducer housing on the face side of the power pack. The auxiliary oil flowrate and coolant flowrate will also be monitored.

TRACTION UNIT

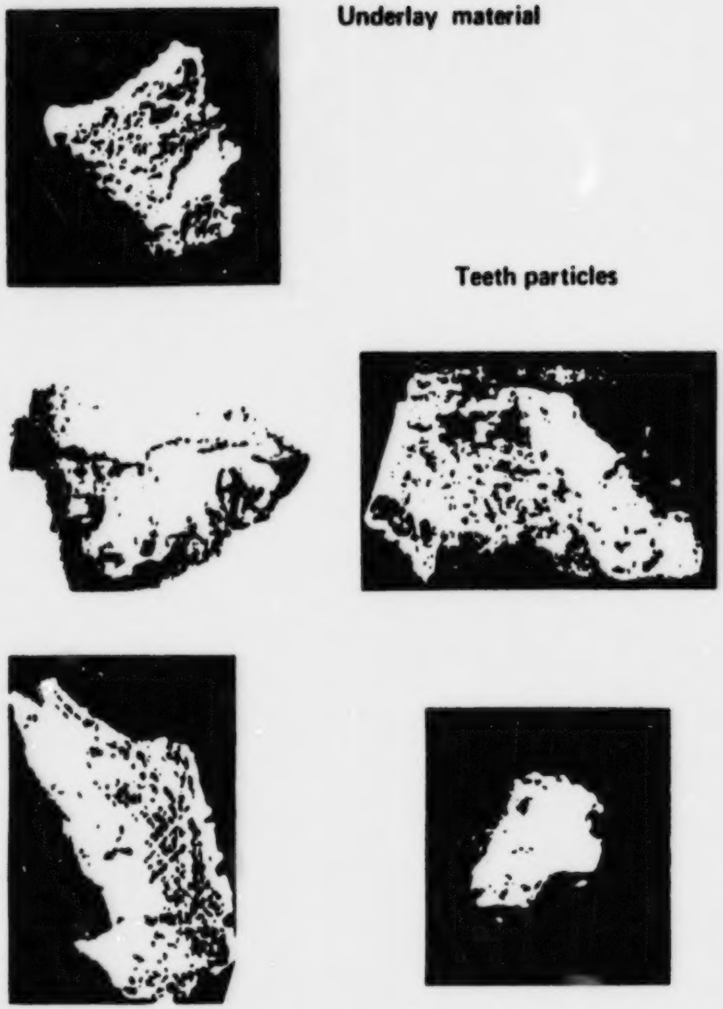
The oil level and temperature in the traction unit will be monitored.

MOTOR

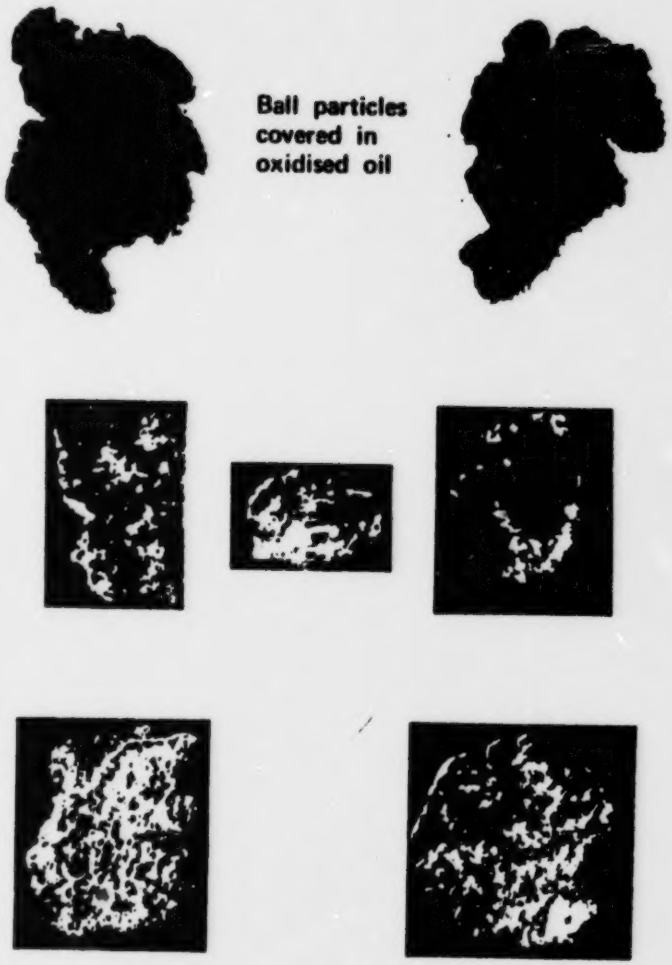
The motor is monitored by the dedicated motor monitoring unit (available without MIDAS) but alerts the MIDAS system when any fault occurs. The nature of the fault is given by the motor monitoring unit, not MIDAS, and will not be displayed on the MIDAS screen or transmitted to the surface if a data transmission system is installed, although the presence of a fault will be displayed and transmitted.

Where data transmission is installed, all transducer values are sent to the surface computer and can provide useful management information on machine status and performance. Trend analysis can be performed on transducer signals, which can be displayed in a graphical or tubular numerical format. Machine downtime can be reduced by spotting detrimental trends and scheduling maintenance accordingly, and data recorded from transducers prior to an unexpected breakdown may facilitate fault diagnosis and decrease downtime.

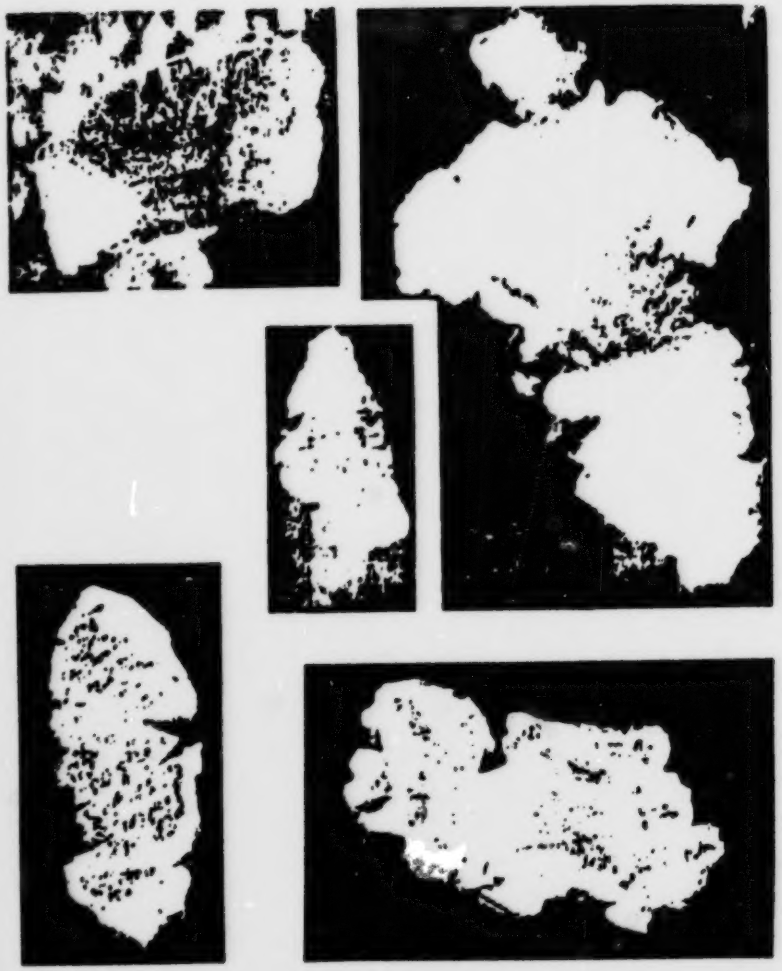
It is Anderson Strathclyde's policy to continually update and improve the facilities offered by the MIDAS computer system and the list of monitored parameters will increase as more transducers are developed and evaluated. Underground trials are presently planned for oil condition transducers and it is anticipated that these will be available in 1986. Development work is continuing in this and other fields to maximise the benefits obtained from condition monitoring of coal face equipment.


Underlay material
Teeth particles

GEAR PARTICLES
x 20 magnification

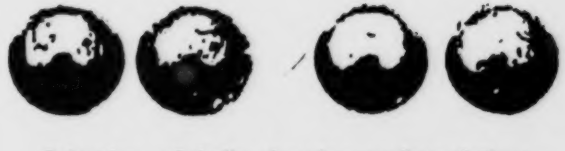

Ball particles
covered in
oxidised oil

BALL PARTICLES
X 20 magnification

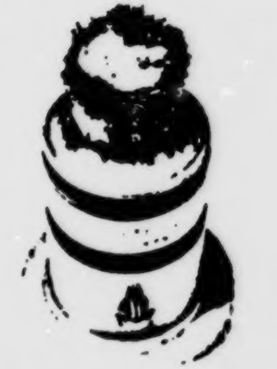


ROLLER PARTICLES
x 20 magnification

Bearing outer race
showing worn track



Selection of balls showing surface fatigue



Magnetic Probe showing debris collected

BEARING FAILURE DETECTION

FIGURE 4

MIDAS DATA TRANSMISSION SYSTEM

MIDAS installations can transmit data along the pilot core. This system requires that a short range multiplexer on the shearer communicates with the long range multiplexer in the gate end enclosure where the signal is extracted from the pilot core. Data is then retransmitted directly to the surface on an approved twisted pair.

On the surface the twisted pair is connected through a BB4 barrier and handshake unit to the surface interface unit which interfaces to the PDP 11 computer. The handshake interface prevents situations arising where both underground and surface transmit data simultaneously along the connecting twisted pair. The surface interface unit contains a long range multiplexer and other hardware to present the data in a form the PDP 11 can accept. Fig. 6 shows this set up.

Alternative data transmission systems may be used where a 7 core (7S) trailing cable is employed. In this a long range multiplexer is fitted to the machine and spare cores are used to transmit data directly through to the twisted pair to the surface. No gate end multiplexer is required.

Surface Equipment Costs

An estimate of the costs of the recommended surface equipment hardware is listed below (February 1985 prices):

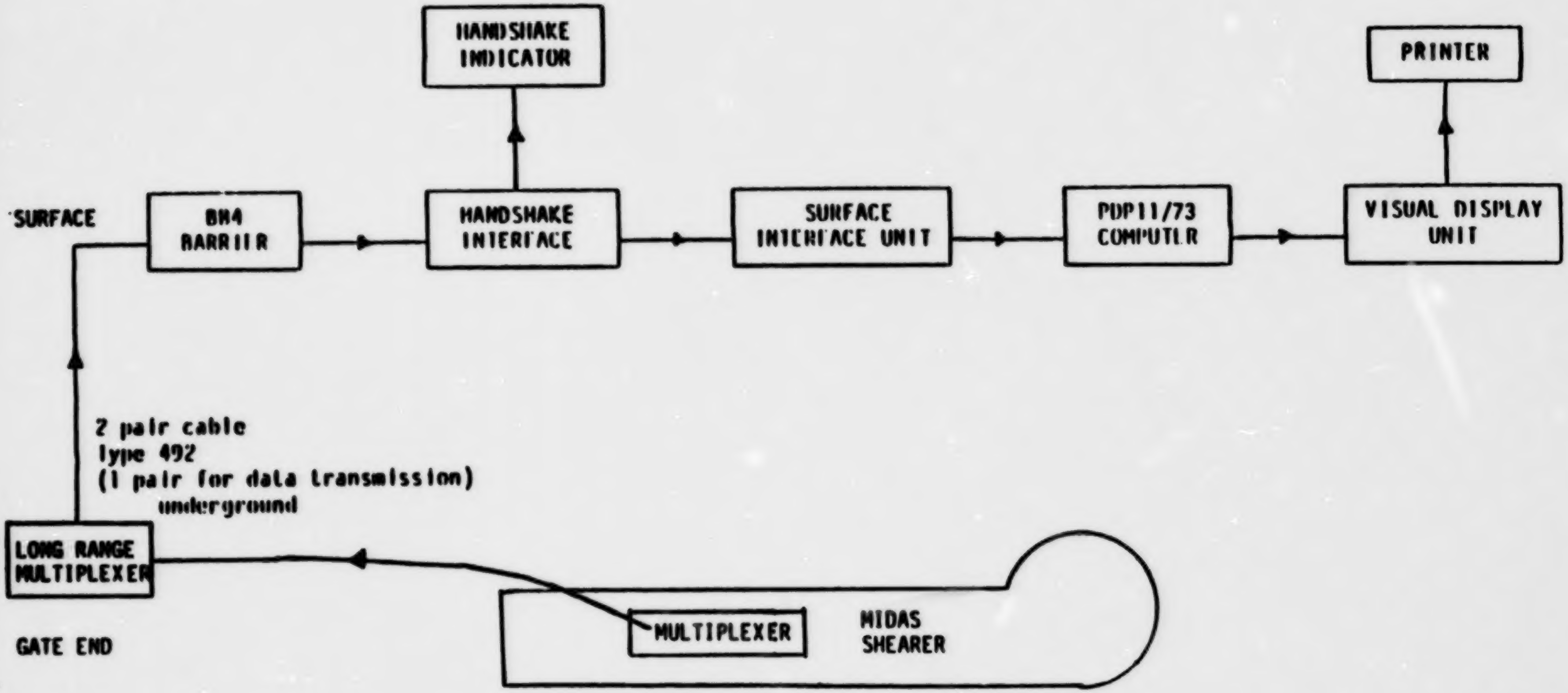
Computer	(9PDP 11-73)	£13,275.00
VDU	(M2250)	2,150.00
Hard copy unit	(Integrex ink jet)	650.00
CVT	(Type 1000D)	290.00
SLC-1 clock		835.00
Surface interface unit		3,300.00
	TOTAL	£20,500.00

Note: These approximate costs do not include the twisted pair link to the surface, BB4 barrier and certain interconnection cables for the surface equipment.

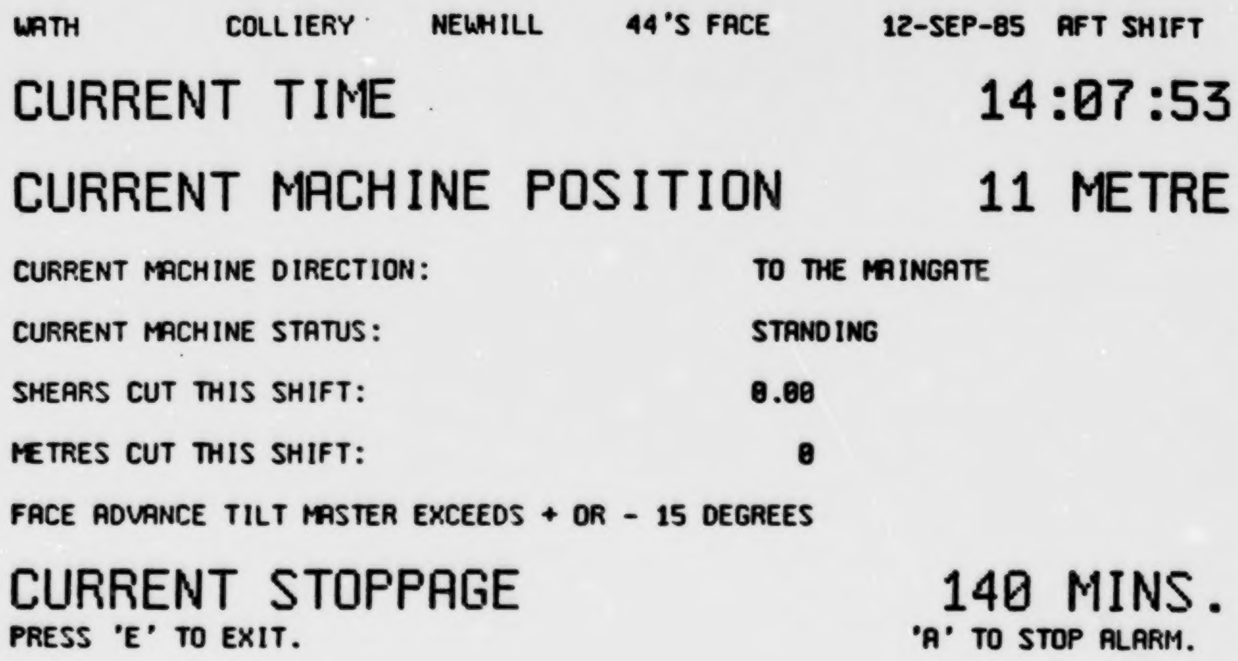
Facilities available on the surface computer

Extensive information is available from the surface equipment. On line information and historical data for the previous 24 shifts is always readily available and it is possible to store date for longer periods simply by changing the disc. This data can then be used for trend analysis, detail production figures or other such tasks.

Fig. 7, 8 and 9 show typical on-line data such as current status, machine position graph and a summary of major delays for a particular shift. Further print-outs obtained from the MIDAS installation on Wath Colliery's N44's face in South Yorkshire Area are given in Appendix 1.

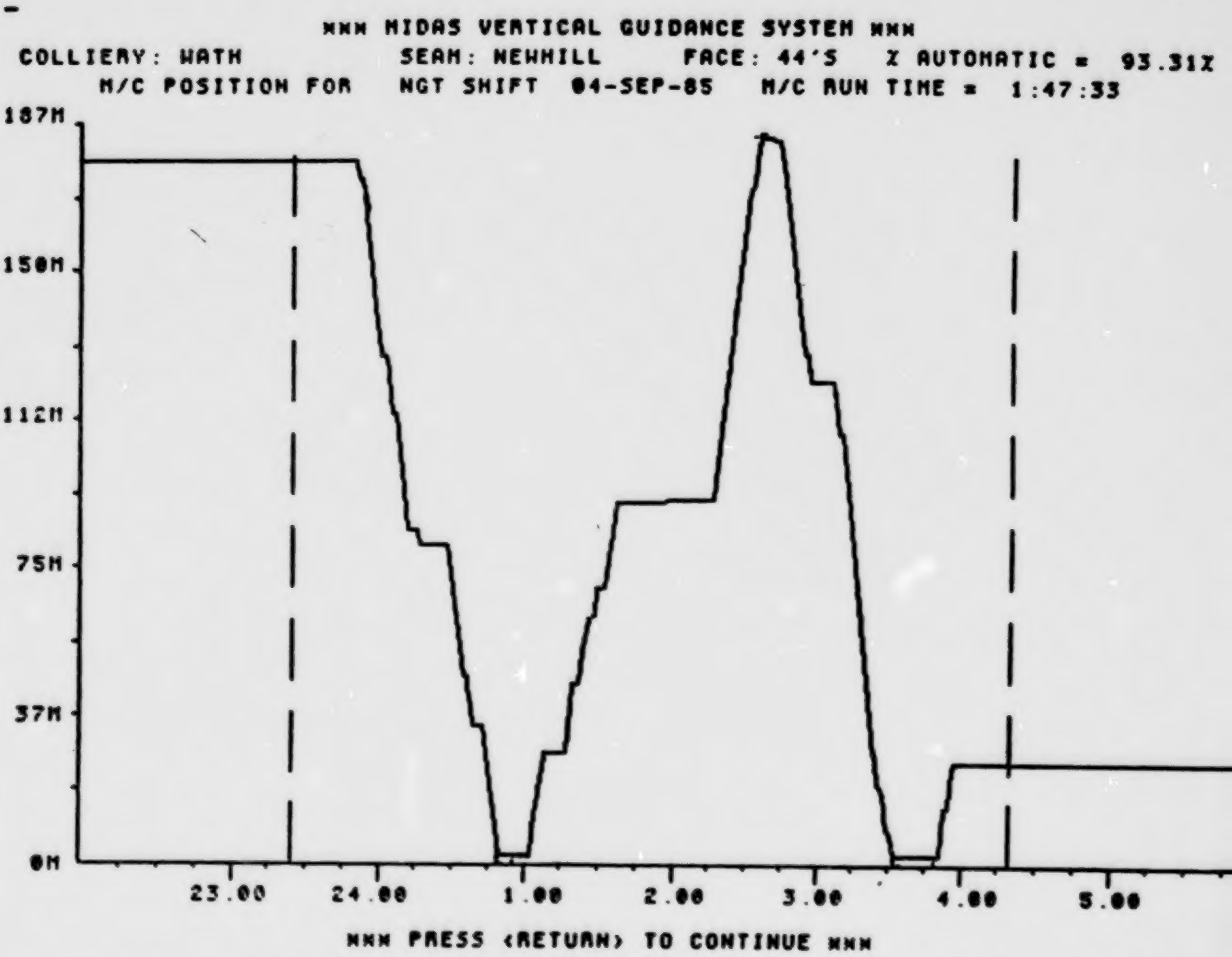


SURFACE
BN4 BARRIER
HANDSHAKE INDICATOR
HANDSHAKE INTERFACE
SURFACE INTERFACE UNIT
PDP11/73 COMPUTER
PRINTER
VISUAL DISPLAY UNIT
2 pair cable
Type 492
(1 pair for data transmission)
underground
LONG RANGE MULTIPLEXER
GATE END
MULTIPLEXER
MIDAS SHEARER



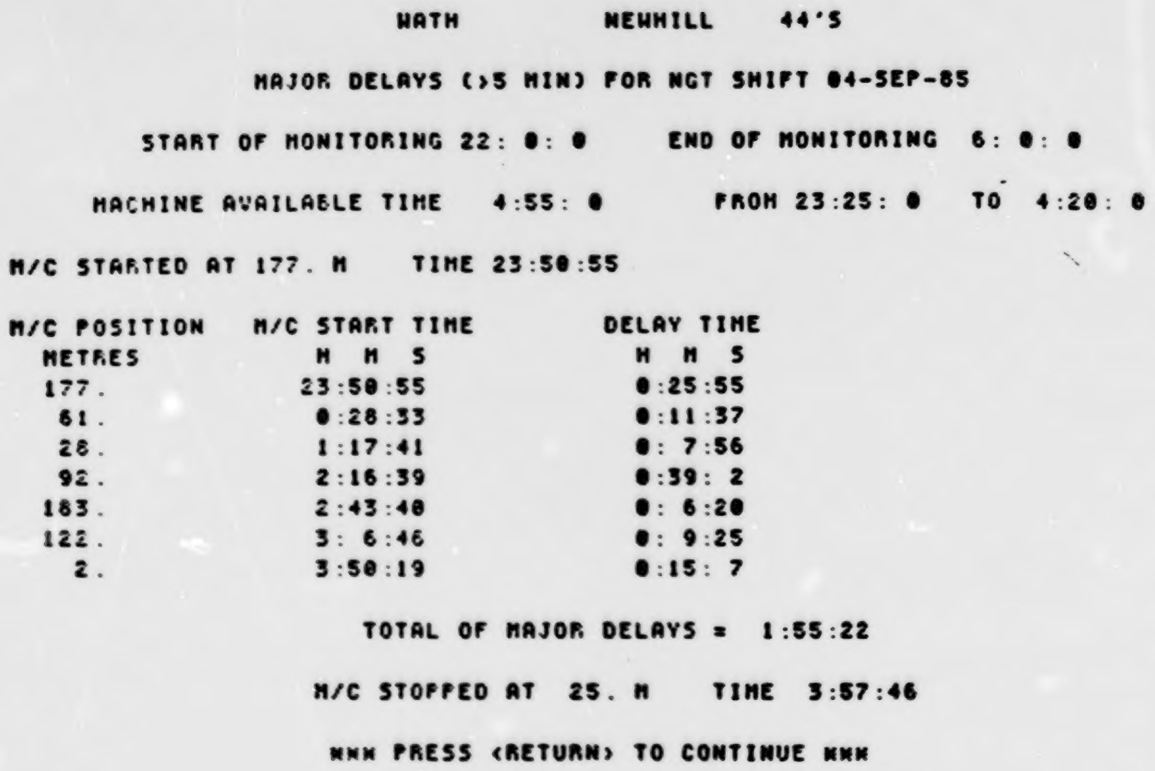
```
WATH          COLLIERY    NEWHILL     44'S FACE       12-SEP-85  AFT SHIFT

CURRENT TIME                                                 14:07:53

CURRENT MACHINE POSITION                                     11 METRE

CURRENT MACHINE DIRECTION:                      TO THE MAINGATE

CURRENT MACHINE STATUS:                         STANDING

SHEARS CUT THIS SHIFT:                          0.00

METRES CUT THIS SHIFT:                             0

FACE ADVANCE TILT MASTER EXCEEDS + OR - 15 DEGREES

CURRENT STOPPAGE                                           140 MINS.
PRESS 'E' TO EXIT.                                  'A' TO STOP ALARM.
```

FIG. 7



```
                      *** MIDAS VERTICAL GUIDANCE SYSTEM ***
COLLIERY: WATH          SEAM: NEWHILL      FACE: 44'S   % AUTOMATIC =  93.31%
    M/C POSITION FOR   NGT SHIFT  04-SEP-85   M/C RUN TIME =  1:47:33
```

```
                      *** PRESS <RETURN> TO CONTINUE ***
```



```
                       WATH          NEWHILL    44'S

            MAJOR DELAYS (>5 MIN) FOR NGT SHIFT 04-SEP-85

      START OF MONITORING 22: 0: 0     END OF MONITORING  6: 0: 0

   MACHINE AVAILABLE TIME   4:55: 0       FROM 23:25: 0   TO  4:20: 0

M/C STARTED AT 177. M    TIME 23:50:55

M/C POSITION   M/C START TIME        DELAY TIME
  METRES          H  M  S              H  M  S
  177.          23:50:55              0:25:55
   61.           0:28:33              0:11:37
   28.           1:17:41              0: 7:56
   92.           2:16:39              0:39: 2
  183.           2:43:40              0: 6:20
  122.           3: 6:46              0: 9:25
    2.           3:50:19              0:15: 7

                 TOTAL OF MAJOR DELAYS =  1:55:22

               M/C STOPPED AT  25. M    TIME  3:57:46

               *** PRESS <RETURN> TO CONTINUE ***
```

FIG. 9

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Financial benefits of automatic steering

Wath Colliery, South Yorkshire Area. N42's and N48's Comparision

The most accurate calculation of the financial benefits of automatic steering was made on a comparison of two virtually identical faces at Wath Colliery, South Yorkshire Area, N48's and N42's. The main difference was that N42's SERDS which cut 86% of the face length, was fitted with System 70000 (the fore-runner of MIDAS), whereas N48's used conventional (non-automatic) SERDS. The faces were worked consecutively 400m apart in the same area of reserves. The chocks and other face equipment were transferred directly from N48's to N42's.

The comparison revealed that N42's was worked out with 73% of the face manshifts and only 70% of the machine shifts previously needed, resulting in an average face productivity improvement of one third, to 20 tons face output per man-shift. Material costs were lowered by 25% and face delays were also significantly reduced, delays from timbering the roof being almost entirely eliminated.

A summary of the prime financial features on a current "PER DAY" basis shows:-

	£ per day
Increased revenue (93 tonnes at £41 per tonne proceeds)	3,813
Savings on face manshifts (7.8 shifts at £40 per shift*)	312
Savings on face materials costs	120
Savings on plant hire charges (£4,600 per week for six weeks = £27,600 186 working days)	148
Debit in district manshifts (1 shift at £25 per shift*)	-25
TOTAL	4,368

(*current overall cost of employing a man)

The improved return of £4368 per working day equates to £0.8M over the ten month period that N42's worked. Alternatively, an additional £728 per strip or £6.5 per minute of MAT was generated on N42's compared to N48's. The total capital cost of System 70000, estimated at MRDE to be £175,000 was retrieved in 40 working days or 92 machine shifts.

Other recorded benefits were:

Improvement in safety of working.
Indications that a lower and more stable emission of firedamp into the general body of the air took place.
The risk of cutting into the floor was virtually eliminated.
Evidence that airborne dust levels were generally reduced.

Current Situation

The first MIDAS installation on N44's face at Wath Colliery, South Yorkshire Area has been operational since March 1985. The face and machine details are:-

Face
Seam : Newhill
Face : N44
Extraction : 1.83m
Length : 178m
Mining System : Left Hand Retreat
Machines : Maingate (Main machine)
AB16 SERDS with MIDAS
Tailgate
AB16 SERDS

MAIN MACHINE SPECIFICATION

Type : AB16 SERDS with MIDAS
Haulage : Mk 1 Hydraulic, 22mm Chain
Motor : 200hp AB16
Control Section : Converted 326B
Gearhead Gearbox : Mk II with 5" raised section
Ranging Arm : Mk III Extended

POWERED SUPPORTS

157 x Gullick Dobson 6/240T Chock Shields

AFC

781mm x 190mm Mk II Line Pans

A comparison of the performance of this MIDAS equipped face can be made with two nearly identical faces at Wath, one fitted with System 70000 and the other with no automatic steering system.

Face Number	48's	42's	44's
		Automatically	
How worked	Manual	System 70000	MIDAS
Type of machine	AB16	AB16	AB16
Mining method	Single Pass	Single Pass	Single Pass
Total machine shifts worked	608	425	249 (to date)
Saleable output/shift(T)	302	411	430
Face advance/shift(m)	0.89	1.26	1.38
Number of strips/shift	1.83	2.63	2.73
Face Area/swept/shift(m^2)	162	231	245

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Performance/Minute of M.A.T.

Face Number	48's	42's	44's
Average M.A.T. (mins)	298	290	288
Saleable output (T)	1.01	1.41	1.49
Face Advance (m)	0.003	0.0043	0.0048
Face Area Swept (m^2)	0.54	0.79	0.85

NB. The above information includes all shifts worked up to 26.7.85.

Continued use of the machine in automatic mode has allowed the roof coal reference to be reduced to 190mm (7.5"). Precise control over this horizon has, despite a slight reduction in seam section, allowed the retention of a 1829mm (72") diameter drum instead of fitting one of 1676mm (66") diameter.

As a result Colliery profits are benefiting by £31,000 for every 50 shears completed, based on pit head prices of £40/tonne.

The installation cost of MIDAS is £140,000 - £180,000 including spares but dependent on the type of machine configuration.

The installation on N44's is due to finish December 1985 when another identical shearer also fitted with MIDAS will commence work on N53's face.

The third MIDAS installation will begin work at the end of October 1985 at Silverwood Colliery, South Yorkshire Area.

Other MIDAS installations are planned for early 1986 in North Derbyshire and Western Areas of the National Coal Board.

The first AM500 installation is planned for early 1986 in either Scottish or Western Area.

TIMESCALES

Anderson Strathclyde PLC consider it very important to plan properly for any MIDAS installations. Due to the complexity of the equipment we advise that 5-6 months is allowed for delivery of the complete machine from receipt of order. The machine will be supplied fully operational and completely tested from our factory.

Detailed specification documents are available from which a bar chart is drawn up to provide a guide through the weeks leading up the the eventual installation and production dates.

APPENDIX 1

WATH SURFACE PRINTOUTS

CONTENTS

Fig. A1: Normal viewing information transmitted every even MMADD pulse if the machine is moving or every 15 secs if machine is stationary and powered up. (see explanation sheet A1A).

Fig. A2: Metric data shown graphically for various sensors. Shown are boom height, coal thickness, machine angle and roof step.

Fig. A3: Summary of major delays for a particular shift.

Fig. A4: Metric data for a particular shift.

Fig. A5: Health data for a particular shift.

Fig. A6: Sensor data for a particular shift

Fig. A7: Face profile for any particular shear in any particular shift.

Fig. A8: Error summary for a particular shift.

The previous 24 shifts are stored after which the system overwrites the disk. If the disc is removed before this happens the previous data can be stored indefinitely.

EXPLANATION OF TERMS ON SHEET FIG. A1

Tilt Gain = 0.8	Determines what value of faceadvance tilt measured is used in the steering calculation. Range is 0.5 to 1.0 in steps of 0.1
Coal Gain = 0.5	Determines what value of coal thickness measured is used in the steering calculation. Range is 0.5 to 1.0 in steps of 0.1
Seam Angle = 25m	Value input via personality unit for seam angle in line of face advance
Coal Ref = 25cm	Roof coal dimension which is optimum
Coal in use = PRE	Predicted steering in use i.e. drum is leading 801 probe. Other type is delayed when probe leads drum
Time	Real time
MMADD Count	Machine movement and direction detector count. In this case counting down towards maingate. Data sent to surface every even count .
Machine Position	In metres from maingate centre line
Control Available	AU = Automatic
Control used	MA = Manual
Mode Switch	AD = Auto defeat
Machine angle	Measured in mm of lift at the drum. (1 degree tilt represents approximately 16mm at the drum)
Coal at Drum	In this case a predicted value in mm
Roof Step	This value is large in this case since the roof follower is in the down position. Value given in normal operation would be the step between present and previous cut
Steering demand	This is the value which the ranging arm would move to obtain the correct horizon. A dead band of ± 10mm is in the system to prevent hunting.
Boom Error	Steering demand -ve roof step gives boom error
Signature Count	Dimensionless numbers in the range 0 to 63. The count is incremented for each scan of data which is sent to the surface and warns of lost data if a count is missed.

FIG. A1A

```
PRESS 'E' TO EXIT . 'A' TO STOP ALARM.                              AFT SHIFT 09-APR-85

TILT GAIN=0.0. COAL GAIN=0.5, SEAM ANGLE=  1.00 DEG, COAL REF=25 CM, COAL IN USE=PRE

  TIME   :NMAND:MACHINE :  CONTROL  :MODE:MACHINE:COAL AT: ROOF :STEERING: BOOM   :SIGN.
         :COUNT:POSITION:AVAIL/USED: SW : ANGLE  : DRUM  : STEP : DEMAND : ERROR  :COUNT
17:28:04   936  96.500MM  AU     MA    AD    17MM    268MM   188MM    -5MM  -193MM    34
17:28:10   934  96.375    AU     MA    AD    16      254     188     -11    -199      35
17:28:16   932  96.125    AU     MA    AD    18      234     188     -23    -211      36
17:28:23   930  95.875    AU     MA    AD    18      242     188     -19    -207      37
17:28:30   928  95.750    AU     MA    AD    16      259     188      -9    -197      38
17:28:35   926  95.500    AU     MA    AD    19      255     188     -13    -201      39
17:28:43   924  95.250    AU     MA    AD    21      254     188     -15    -203      40
17:28:50   922  95.125    AU     MA    AD    22      255     188     -16    -204      41
17:28:59   920  94.875    AU     MA    AD    21      251     188     -17    -205      42
17:29:07   918  94.625    AU     MA    AD    19      267     188      -7    -195      43
17:29:16   916  94.500    AU     MA    AD    18      261     188      -9    -197      44
17:29:26   914  94.250    AU     MA    AD    16      271     188      -3    -191      45
17:29:35   912  94.000    AU     MA    AD    16      262     188      -7    -195      46
17:29:44   910  93.875    AU     MA    AD    16      254     188     -11    -199      47
17:29:55   908  93.625    AU     MA    AD    14      266     189      -4    -193      48
17:30:03   906  93.375    AU     MA    AD    17      264     189      -7    -196      49
17:30:12   904  93.250    AU     MA    AD    18      245     189     -17    -206      50
17:30:20   902  93.000    AU     MA    AD    16      264     189      -6    -195      51
17:31:16   902  93.000    AU     MA    AD    17      264     189      -7    -196      52
17:31:22   900  92.875    AU     MA    AD    19      252     189     -15    -204      53
17:31:29   898  92.625    AU     MA    AD    21      239     189     -23    -212      54
```

FIG. A.1   NORMAL ON-LINE STEERING DATA

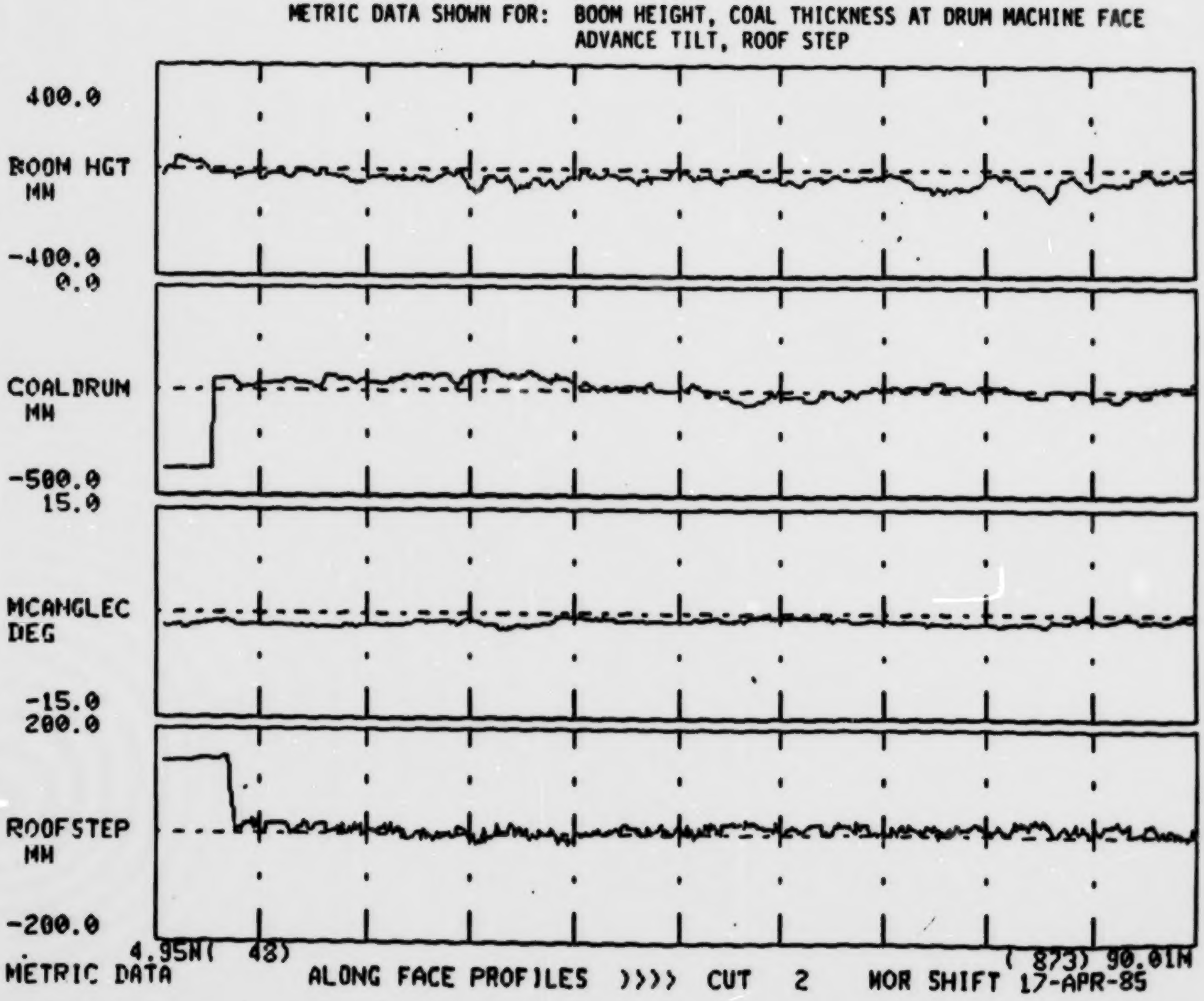
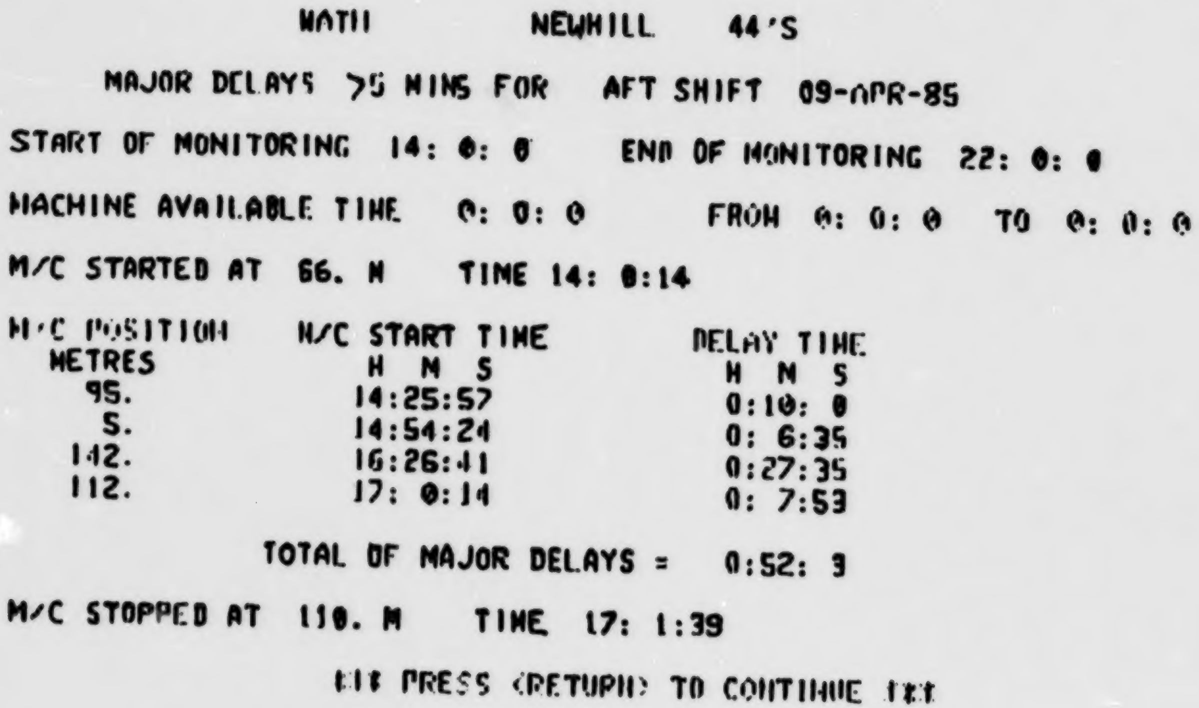


FIG A2 METRIC DATA



```
                    MATH          NEWHILL    44'S

         MAJOR DELAYS >5 MINS FOR   AFT SHIFT  09-APR-85

START OF MONITORING  14: 0: 0     END OF MONITORING  22: 0: 0

MACHINE AVAILABLE TIME   0: 0: 0       FROM  0: 0: 0   TO  0: 0: 0

M/C STARTED AT  66. M    TIME 14: 0:14

M/C POSITION    M/C START TIME          DELAY TIME
  METRES            H  M  S               H  M  S
    95.           14:25:57               0:10: 0
     5.           14:54:24               0: 6:35
   142.           16:26:41               0:27:35
   112.           17: 0:14               0: 7:53

              TOTAL OF MAJOR DELAYS =    0:52: 3

M/C STOPPED AT  110. M    TIME  17: 1:39

                  *** PRESS <RETURN> TO CONTINUE ***
```

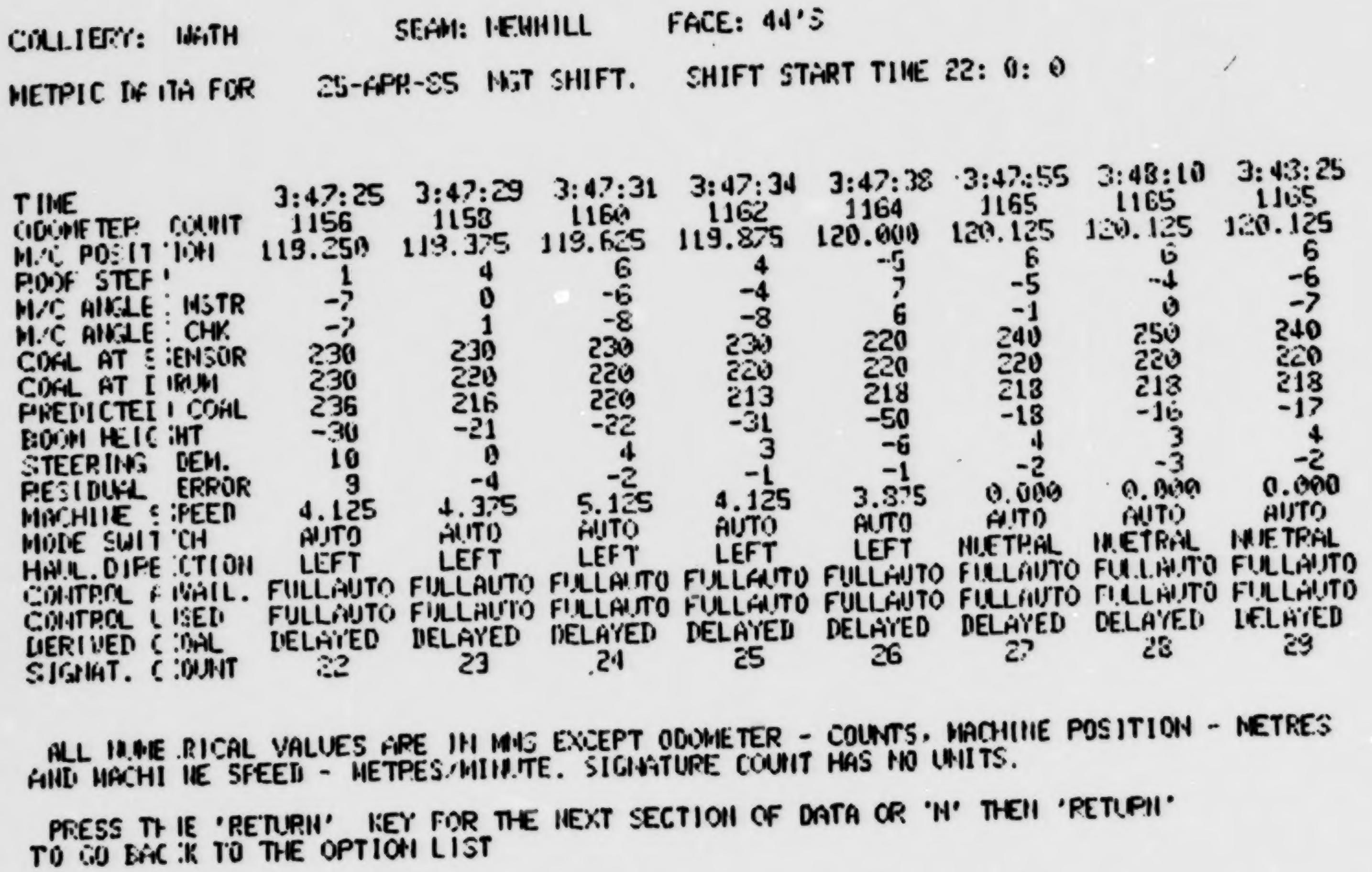
FIG A3 SUMMARY OF MAJOR DELAYS FOR A SHIFT

```
COLLIERY: WATH          SEAM: NEWHILL     FACE: 44'S

SENSOR DATA FOR    09 APR 85  AFT SHIFT.   SHIFT START TIME 14: 0: 0


TIME              14: 0:14 14: 0:14 14: 0:17 14: 0:23 14: 0:29 14: 0:35 14: 0:41 14: 0:46
ODOMETER COUNT       686      684      682      680      678      676      674      672
M/C ANGLE MSTR     4.180    4.188    4.192    4.208    4.216    4.212    4.204    4.232
M/C ANGLE CHK      4.144    4.144    4.148    4.160    4.164    4.180    4.192    4.184
ROOM HEIGHT        3.676    3.652    3.740    3.756    3.756    3.756    3.756    3.840
ROOF COAL             59       51       40       48       64       47       54       57
ROOF FOLLOWER      5.584    5.584    5.584    5.584    5.584    5.584    5.584    5.584
ALONG FCE TILT     4.448    4.476    4.468    4.476    4.424    4.408    4.404    4.404
RESET DEVICE       5.596    5.592    5.592    5.592    5.592    5.592    5.596    5.592
HAUL.DIRECTION     5.400    5.396    5.400    5.400    5.400    5.400    5.400    5.400
10V HINAS SUPP     9.960    9.960    9.960   10.000   10.000    9.960    9.960    9.960
 5V HINAS SUPP     4.940    4.940    4.940    4.920    4.940    4.940    4.940    4.940
A-D CON.STATUS   HEALTHY  HEALTHY  HEALTHY  HEALTHY  HEALTHY  HEALTHY  HEALTHY  HEALTHY
CONTROL AVAIL.  FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO
CONTROL USED     MANUAL   MANUAL   MANUAL   MANUAL   MANUAL   MANUAL   MANUAL   MANUAL
SIGNAT. COUNT       57       58       59       60       61       62       63        0


ALL NUMERICAL VALUES ARE IN VOLTS EXCEPT ODOMETER - COUNTS AND ROOF COAL - COUNTS PER
GATE TIME. SIGNATURE COUNT HAS NO UNITS.


PRESS THE 'RETURN'  KEY FOR THE NEXT SECTION OF DATA OR 'N' THEN 'RETURN'
TO GO BACK TO THE OPTION LIST
```

FIG A4 METRIC DATA

```
COLLIERY: WATH          SEAM: NEWHILL     FACE: 44'S

HEALTH DATA FOR    09-APR-85  AFT SHIFT.    SHIFT START TIME 14: 0: 0


TIME              14: 0:14 14: 0:15 14: 0:17 14: 0:23 14: 0:29 14: 0:35 14: 0:41 14: 0:46
ODOMETER COUNT        626      684      682      680      678      676      674      672
AUX. HAUL PRES      -1000       21    -1000        0    -1000    -1000    -1000      143
ROOF FOL. PRES          0        0        0        0        0        0        0        0
HAUL.PRES.LEFT          4       17       17       17        0       21       17       12
HAUL.PRES.RGHT        120      132      116      116      112      112      124      116
BOOM RAISE PRS    -20.00    -20.00   -20.00   -20.00   -20.00   -20.00   -20.00   -20.00
BOOM LOWER PRS   -200.00   -200.00  -200.00  -200.00  -200.00  -200.00  -200.00  -200.00
BOOM OIL FLOW    -200.00   -200.00  -200.00  -200.00  -200.00  -200.00  -200.00  -200.00
NOT CONNECTED     30.000    26.000   24.000   34.000   30.000   24.000   30.000   22.000
NOT CONNECTED    -200.00   -200.00  -200.00  -200.00  -200.00  -200.00  -200.00  -200.00
NOT CONNECTED          0         0        0        0        0        0        0        0
NOT CONNECTED          0         0        0        0        0        0        0        0
NOT CONNECTED          0         0        0        0        0        0        0        0
NOT CONNECTED          0         0        0        0        0        0        0        0
SIGNAT. COUNT         57        58       59       60       61       62       63        0


ALL PRESSURE VALUES ARE IN BARS, FLOW VALUES IN LITRES PER MINUTE AND
TEMPERATURE IN DEGREES CENTIGRADE. SIGNATURE COUNT HAS NO UNITS


PRESS THE 'RETURN'  KEY FOR THE NEXT SECTION OF DATA OR 'N' THEN 'RETURN'
TO GO BACK TO THE OPTION LIST
```

FIG A5 HEATH DATA



```
COLLIERY:  WATH           SEAM: NEWHILL    FACE: 44'S

METRIC DATA FOR    25-APR-85  NGT SHIFT.   SHIFT START TIME 22: 0: 0


TIME               3:47:25  3:47:29  3:47:31  3:47:34  3:47:38  3:47:55  3:48:10  3:48:25
ODOMETER  COUNT      1156     1158     1160     1162     1164     1165     1165     1165
M/C POSITION       119.250  119.375  119.625  119.875  120.000  120.125  120.125  120.125
ROOF STEP               1        4        6        4       -5        6        6        6
M/C ANGLE MSTR         -7        0       -6       -4        7       -5       -4       -6
M/C ANGLE CHK          -7        1       -8       -8        6       -1        0       -7
COAL AT SENSOR        230      230      230      230      220      240      250      240
COAL AT DRUM          230      220      220      220      220      220      220      220
PREDICTED COAL        236      216      220      213      218      218      218      218
BOOM HEIGHT           -30      -21      -22      -31      -50      -18      -16      -17
STEERING  DEM.         10        0        4        3       -6        4        3        4
RESIDUAL  ERROR         9       -4       -2       -1       -1       -2       -3       -2
MACHINE SPEED       4.125    4.375    5.125    4.125    3.875    0.000    0.000    0.000
MODE SWITCH          AUTO     AUTO     AUTO     AUTO     AUTO     AUTO     AUTO     AUTO
HAUL.DIRECTION       LEFT     LEFT     LEFT     LEFT     LEFT  NUETRAL  NUETRAL  NUETRAL
CONTROL AVAIL.   FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO
CONTROL USED     FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO FULLAUTO
DERIVED COAL      DELAYED  DELAYED  DELAYED  DELAYED  DELAYED  DELAYED  DELAYED  DELAYED
SIGNAT. COUNT          22       23       24       25       26       27       28       29

 ALL NUMERICAL VALUES ARE IN MMS EXCEPT ODOMETER - COUNTS, MACHINE POSITION - METRES
AND MACHINE SPEED - METRES/MINUTE. SIGNATURE COUNT HAS NO UNITS.

 PRESS THE 'RETURN'  KEY FOR THE NEXT SECTION OF DATA OR 'N' THEN 'RETURN'
TO GO BACK TO THE OPTION LIST
```

FIG A6 SENSOR DATA FOR A SHIFT

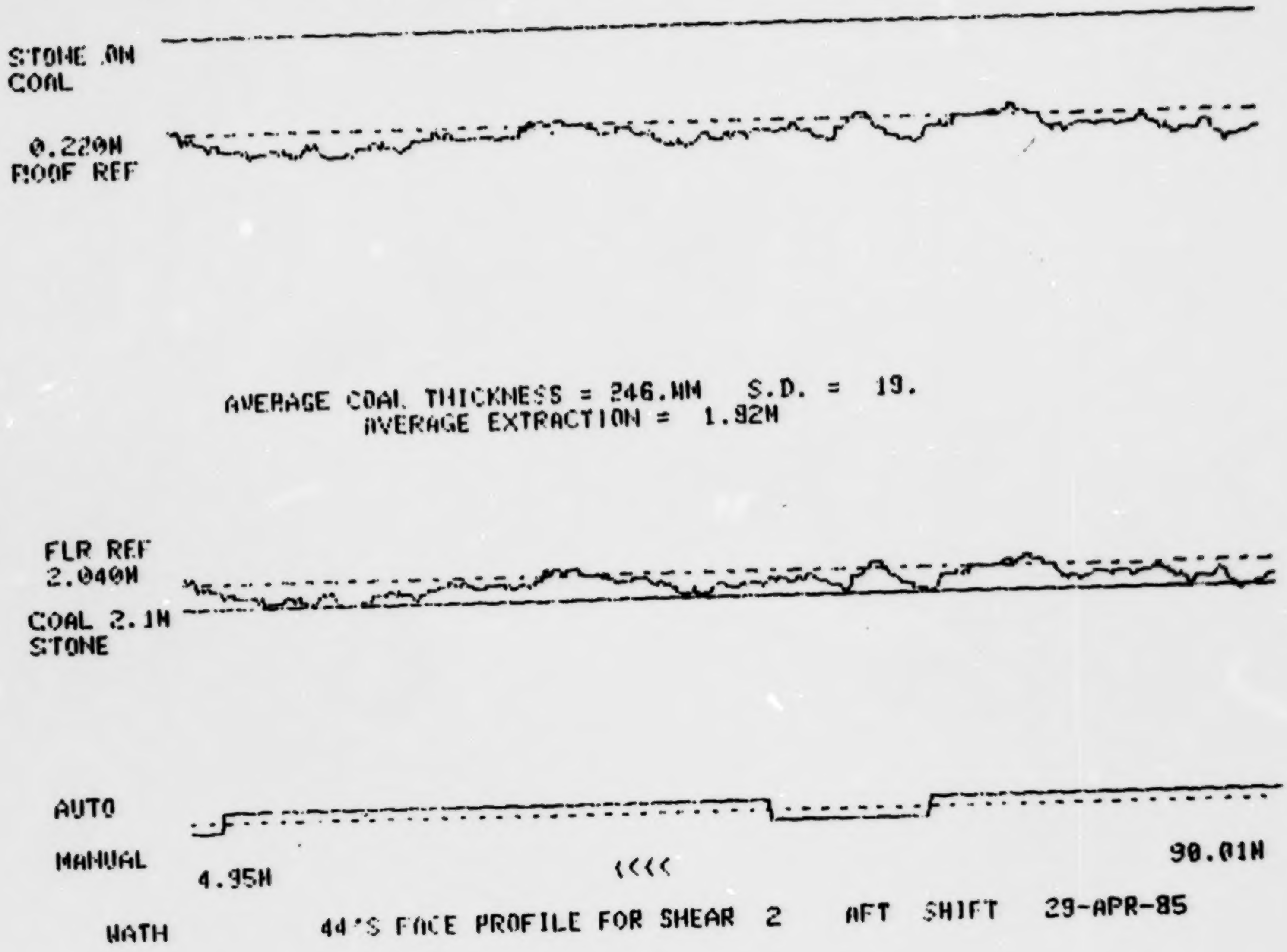


FIG A7 FACE PROFILE FOR HALF OF A SHEAR

```
COLLIERY: WATH          SEAM: NEWHILL     FACE: 44'S

ERROR SUMMARY FOR    09-APR-85  AFT SHIFT. SHIFT START TIME 14: 0: 0

ERROR FATAL NON-FATAL        DESCRIPTION
  104     0      1   SURFACE EXECUTIVE FORMAT ERROR - MESSAGE LOST !!!
  105     0      1   SURFACE MULTIPLEXER UNEXPECTED CODE RECEIVED
  106     0      1   DATA HANDLER SCAN BUFFER FULL
  257     1      0  MMADD COUNT OUT OF RANGE 0 TO 3500
  275     0      2  BOOM RAISE PRESSURE TRANSDUCER UNDERRANGE
  276     0      1  BOOM LOWER PRESSURE TRANSDUCER UNDERRANGE
  277     0      4  277
  278     0     20  279
  279     0      2  279

NO MORE DATA IN THE FILE. PRESS <RETURN> TO CONTINUE.
```

FIG A8 ERROR SUMMARY FOR A SHIFT

MIDAS CONTROL SYSTEM

STEERING PHILOSOPHY

CHAPTER TWO: STEERING PHILOSOPHY

2.1 INTRODUCTION:

On manually controlled shearers the operator steers the machine by raising or lowering the Ranging Arms from the electrical end stations. The operator must determine the optimum position of the ranging arm in order to leave the correct thickness of roof coal or to avoid cutting stone roof, often without the aid of any visible marker bands. At the same time, he must take into consideration not only the angle of the machine relative to face advance, but also look for humps and swilleys along the face length. These steering elements are not easy to reconcile for optimum machine performance.

MIDAS however removes control of the ranging arms from the operator and will automatically keep the machine on the correct horizon. This is achieved by automatic control of Ranging Arm raise and lower functions in response to changes in face conditions, which would otherwise result in the correct horizon being lost.

2.2 AUTOMATIC CONTROL:

On the MIDAS AM500 control of the Ranging Arms can be effected in 2 modes, determined by the selector switch position on the Monitoring and Control box -

Auto Defeat (manual control)
Auto Control

2.2.1 In Auto Defeat the Ranging Arms can be raised or lowered from either the PB8 electrical end stations or from a radio transmitter, dependent on the switch position on the Monitoring and Control box.

2.2.2 In Auto Control the function of raising and lowering the Ranging Arms is removed from the PB8's and radio transmitter control and is placed under MIDAS control. Depending on the mining method selected, see Commissioning Chapter Four, one or both roof followers will rise to the roof and the drums will be positioned by the closed loop control system. Steering demands are then calculated by the steering algorithm, and the low pressure solenoid operated valves on the face side of the Monitoring and Control box are activated by MIDAS to raise or lower the Ranging Arms.

2.3 STEERING ALGORITHM : FIG.2.1

The Steering Algorithm uses the following inputs :

The roof follower
The machine angle in line of face advance.

2.3.1 The Roof Follower Control Loop

The Roof Follower control loop uses the hydraulically-operated Roof Follower arm which follows the previous cut roof. Control loop calculations are made every 100ms by MIDAS.

The Roof Follower Transducer produces a voltage proportional to the angle between the Roof Follower Arm and its theoretical zero position parallel to the Ranging Arm Centre Line. When the signal from the transducer is equivalent to the Roof Follower Reference the resulting step in roof, as summed at (B) is zero. In these circumstances the contact point of the Roof Follower Arm is level with the top pick point on the cutting drum and the machine is said to be 'on reference'.

If the Roof Follower Arm moves 'off reference' the summation at (B) produces an error voltage, this being positive for an upward movement of the Roof Follower Arm. MIDAS then activates the electro-hydraulic interface and the Ranging Arm is raised or lowered accordingly to create a step in the roof. Movement of the Ranging Arm causes the Roof Follower Arm to be compressed or released, this causing the signal from the Roof Follower Transducer to alter. When the summation of the Roof Follower signal and the Roof Follower reference is again zero i.e. 'on reference', Ranging Arm movement will cease.

To prevent the control loop from hunting about the reference point, the error voltage output from the summing device (C) is subjected to a deadband circuit which prevents MIDAS from acting on small steering demands of less than ± 10mm. However, steering demands in excess of this are acted upon in full, producing equivalent movements of the ranging arm.

2.3.2 Machine Angle algorithm :

The angle of the cutting drum with respect to the horizontal, in line of coalface advance, is measured by the Face Advance Tilt transducer. The tilt transducer produces a voltage proportional to machine tilt angle, which is relayed to the MIDAS Unit.

Comparator (A) compares the Face Advance Tilt signal with the Seam Angle Reference entered into the Personality Unit at commissioning, see 4.8.9. A software conversion factor is applied to Machine Angle error converting from angular to linear measurement. The conversion factor is such that one degree of tilt is converted to 16mm displacement of the face side of the cutting drum.

A Machine Angle Gain Factor is set into the Personality Unit at commissioning and sets the system sensitivity such that it is responsive but not liable to overshoot. The gain factor has a value between 0 and 1, a figure of 0.8 generally being set. The limited Machine Angle error signal is then tested against the Roof Step Limit.

2.3.3 Steering Demand Generation :

The steering demand requested by the Machine Angle Error signal is tested against the Roof Step Limit which prevents MIDAS from generating a roof step of more than 40mm for machine angles of up to four degrees. In exceptional circumstances when machine angle exceeds four degrees the Roof Step Limit may be increased in proportion to the machine angle, up to a maximum step of 65mm. Large roof steps between successive shears are avoided and any errors are corrected gradually over several passes.

The Roof Follower Signal is compared at (B) with the Roof Follower Reference to give the Step In Roof. This is then compared at (C) with the Steering Demand to give the Steering Error. If the Steering Error is outside the deadband limits (i.e. ± 10mm) corrective steering action, back to the centre of the deadband, takes place.

2.3.4 Ranging Arm Loop Control-Double Pass Operation: Fig 2.2;

For a machine operating a double pass mining method the steering philosophy changes when the floor cut is made. The Ranging Arm loop control is implemented depending on haulage direction.

During a roof cut, Ranging Arm height readings are stored in MIDAS at each MMADD count.

On the return floor cut these stored Ranging Arm height values are compared at (A) with the desired extraction less the drum diameter to produce a Ranging Arm reference signal. This is compared at (B) with the preset Ranging Arm height to produce a steering error. If the steering error is greater than the deadband (± 10mm) the Ranging Arm is raised or lowered to reduce the error to zero.

In this way a constant extraction is maintained throughout the coalface.

2.4 AUTOMATIC CONTROL

2.4.1 Single Pass DERDS : Figs. 4.5 and 4.6

2.4.1.1 The leading drum algorithm uses :

a) The current machine angle in face advance, measured with respect to the seam angle.

b) The step in the roof between present and previous machine passes, measured at the drum centre line.

2.4.1.2 The trailing drum algorithm uses :

a) The current machine angle in face advance, measured with respect to seam angle.

b) The step in the roof between present and previous machine passes, measured at the drum centre line, modified by the extraction from personality minus the drum diameter from personality.

2.4.1.3 In automatic both roof followers are activated.

2.4.2 Double Pass DERDS : Fig. 4.7 to 4.10

2.4.2.1 The leading drum algorithm for the roof cut uses :

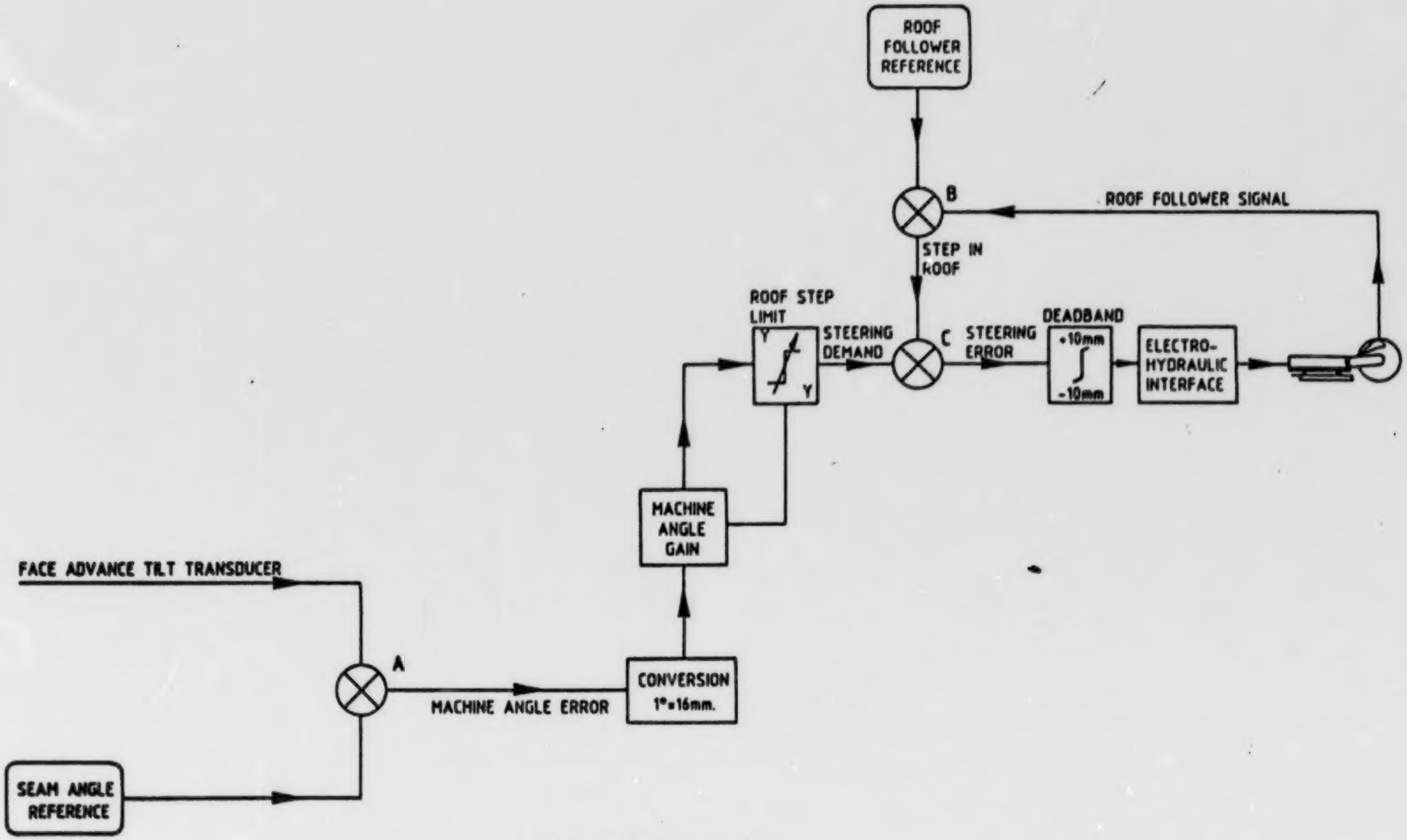
a) The current machine angle in face advance, measured with respect to seam angle.

b) The step in the roof between present and previous machine passes, measured at the drum centre line.

2.4.2.2 On the return pass the leading drum in 2.4.2.1 becomes the trailing drum and uses the ranging arm loop control algorithm as described in 2.3.4.

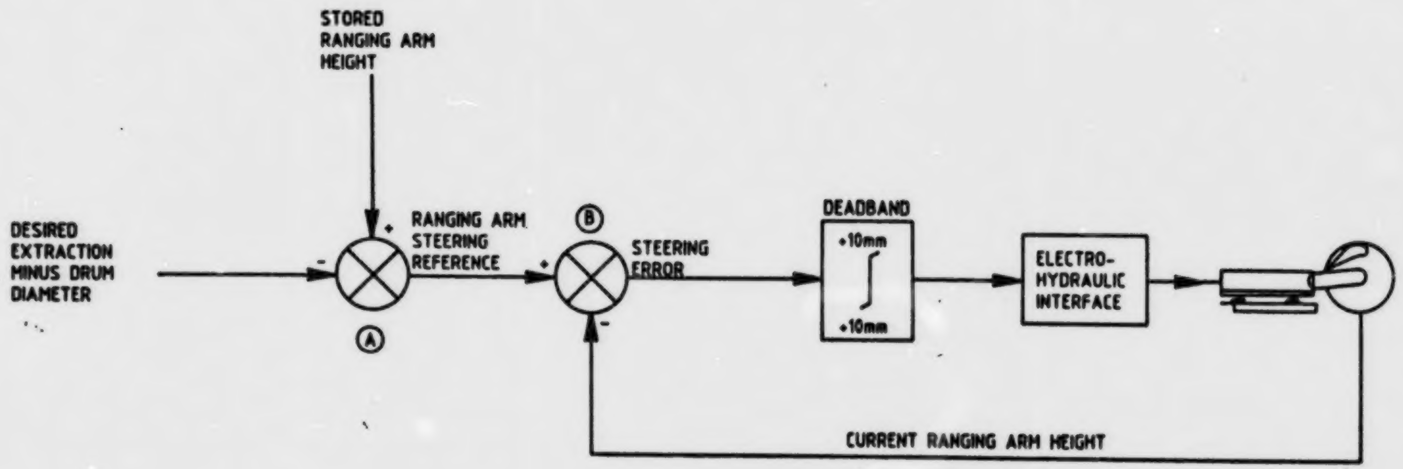
2.4.2.3 The trailing drum during operation 2.4.2.1 which becomes the leading drum during operation 2.4.2.2 is controlled by the extraction set during commissioning. The closed loop control system maintains the cutting drum in the desired position.

2.4.2.4 In automatic only the leading drum roof follower is activated and only during the roof cut. On the floor cut both roof followers are down.


ROOF FOLLOWER REFERENCE
B
ROOF FOLLOWER SIGNAL
STEP IN ROOF
ROOF STEP LIMIT
Y
Y
STEERING DEMAND
C
STEERING ERROR
DEADBAND
+10mm
-10mm
ELECTRO-HYDRAULIC INTERFACE
MACHINE ANGLE GAIN
FACE ADVANCE TILT TRANSDUCER
A
MACHINE ANGLE ERROR
CONVERSION 1°=16mm.
SEAM ANGLE REFERENCE

MIDAS CONTROL SYSTEM:
STEERING ALGORITHM

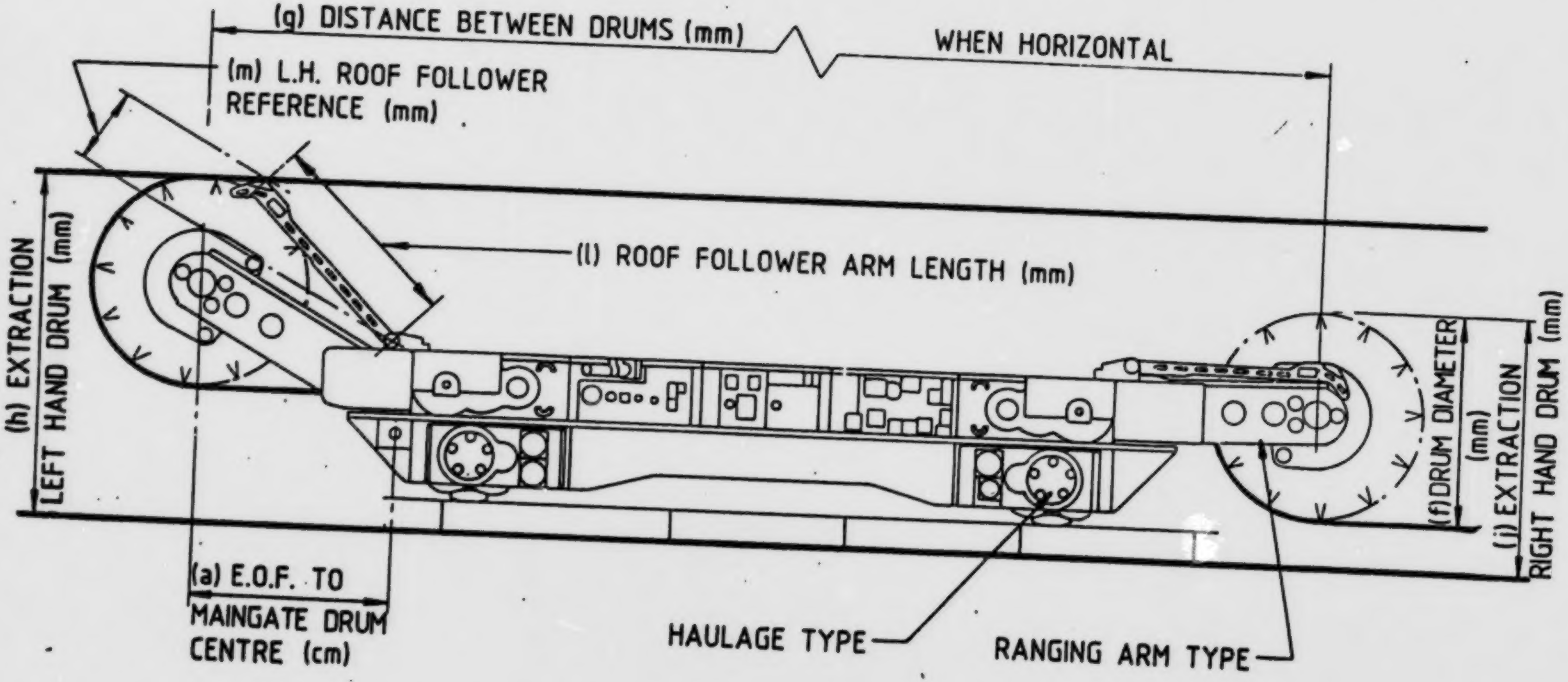
FIG. 2.1


STORED
RANGING ARM
HEIGHT
DESIRED
EXTRACTION
MINUS DRUM
DIAMETER
-
+
A
RANGING ARM
STEERING
REFERENCE
B
+
-
STEERING
ERROR
DEADBAND
+10mm
+10mm
ELECTRO-
HYDRAULIC
INTERFACE
CURRENT RANGING ARM HEIGHT

MIDAS CONTROL SYSTEM:
RANGING ARM LOOP CONTROL
–DOUBLE PASS OPERATION

FIG. 2.2

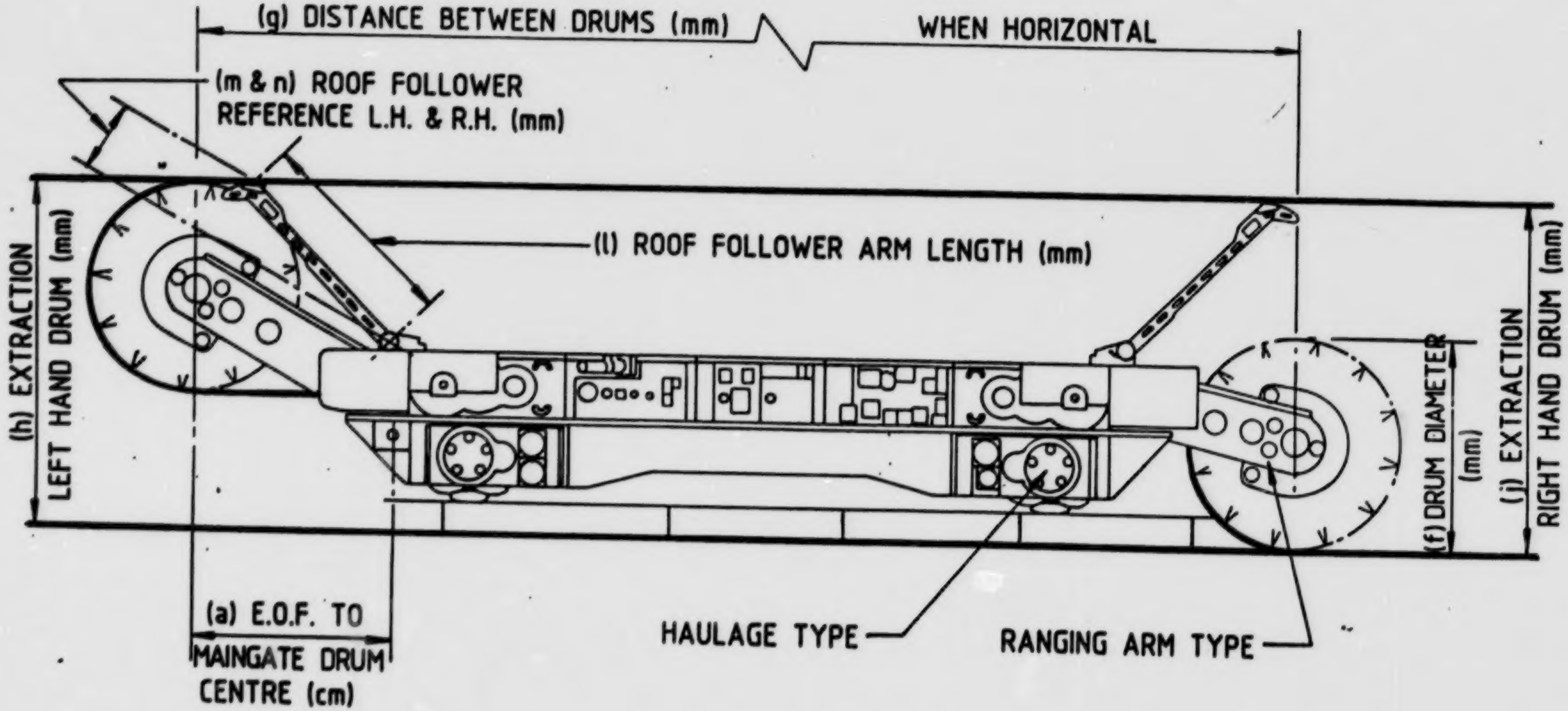
NOTE: D.E.R.D.S. VIEWED FROM GOAF SIDE (MAINGATE DRUM IS THE LEFT HAND DRUM IN THIS EXAMPLE)


(g) DISTANCE BETWEEN DRUMS (mm)
WHEN HORIZONTAL
(m) L.H. ROOF FOLLOWER REFERENCE (mm)
(l) ROOF FOLLOWER ARM LENGTH (mm)
(h) EXTRACTION LEFT HAND DRUM (mm)
(f) DRUM DIAMETER (mm)
(j) EXTRACTION RIGHT HAND DRUM (mm)
(a) E.O.F. TO MAINGATE DRUM CENTRE (cm)
HAULAGE TYPE
RANGING ARM TYPE

PERSONALITY DRAWING FOR D.E.R.D.S.
DOUBLE PASS MINING METHODS
19, 20, 21, & 22

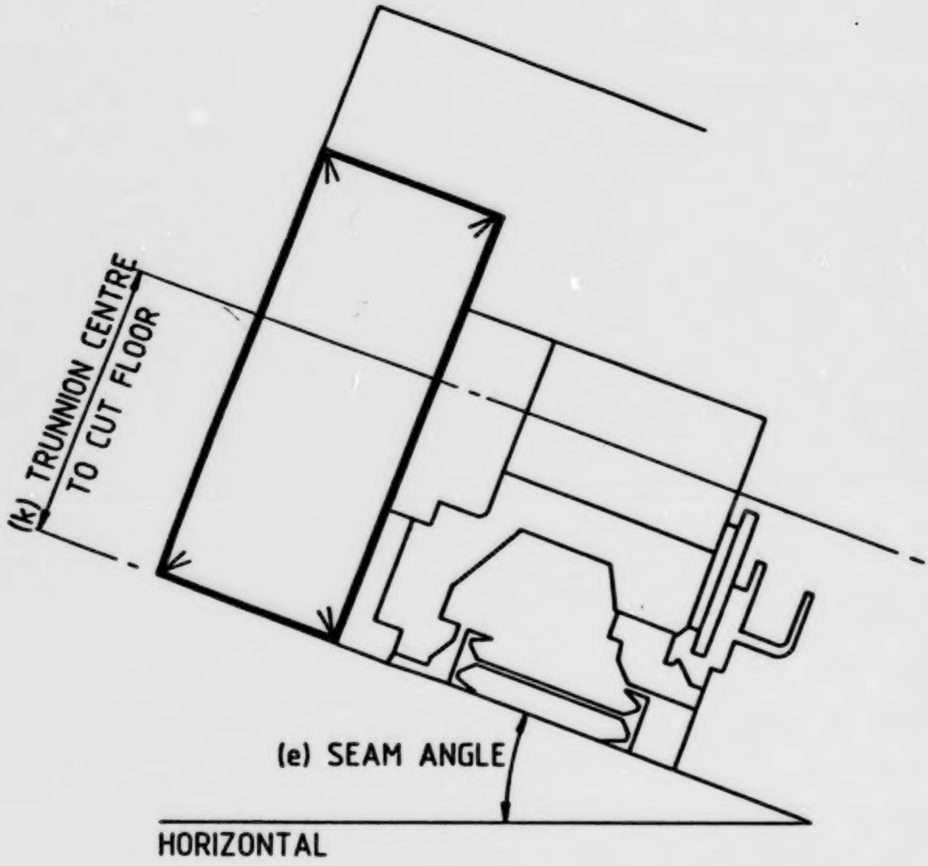
FIG. 4.1

NOTE: D.E.R.D.S. VIEWED FROM GOAF SIDE (MAINGATE DRUM
IS THE LEFT HAND DRUM IN THIS EXAMPLE)


(g) DISTANCE BETWEEN DRUMS (mm) WHEN HORIZONTAL
(m & n) ROOF FOLLOWER REFERENCE L.H. & R.H. (mm)
(l) ROOF FOLLOWER ARM LENGTH (mm)
(h) EXTRACTION LEFT HAND DRUM (mm)
(f) DRUM DIAMETER (mm)
(j) EXTRACTION RIGHT HAND DRUM (mm)
(a) E.O.F. TO MAINGATE DRUM CENTRE (cm)
HAULAGE TYPE
RANGING ARM TYPE

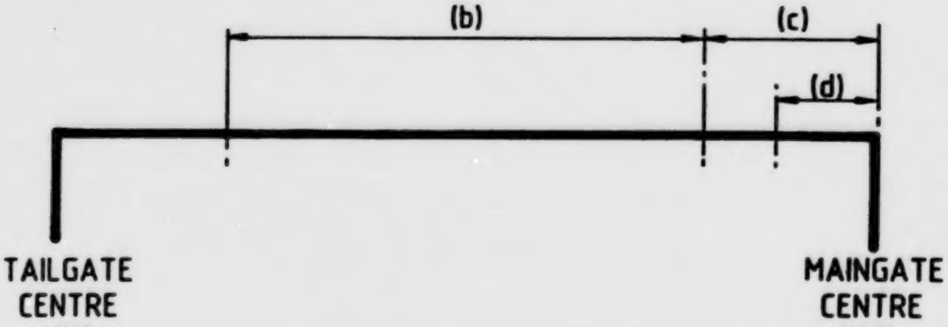
PERSONALITY DRAWING FOR D.E.R.D.S.
SINGLE PASS MINING METHODS 13 & 14

FIG. 4.2

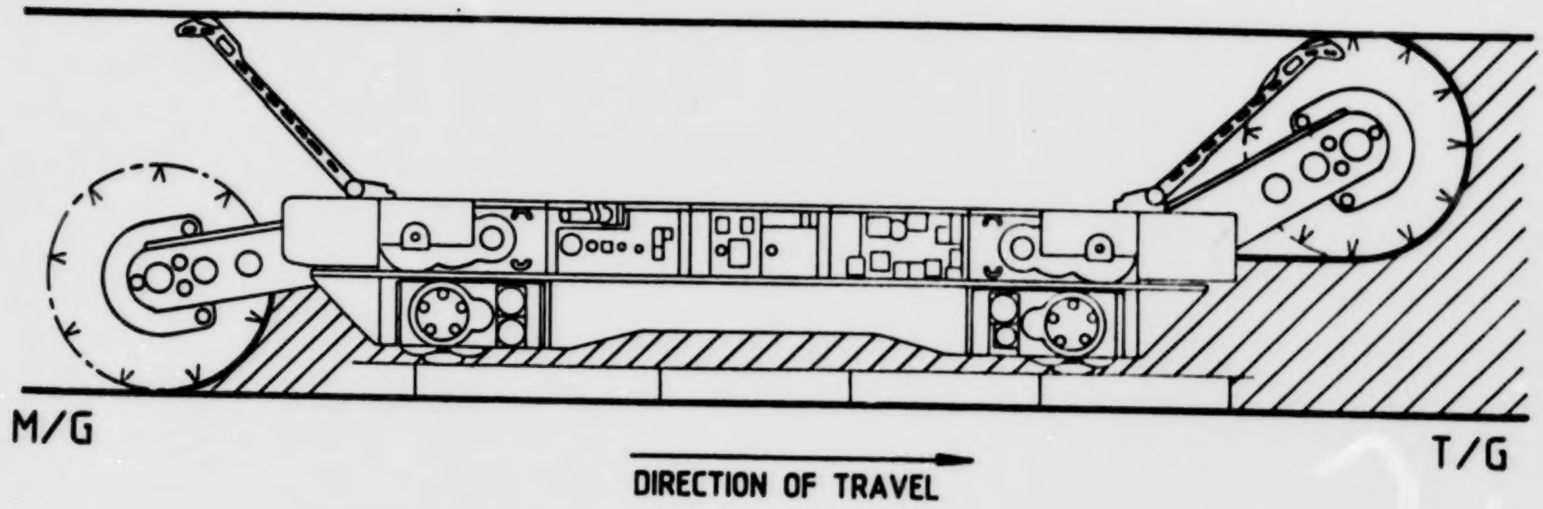

(k) TRUNNION CENTRE TO CUT FLOOR
(e) SEAM ANGLE
HORIZONTAL

PERSONALITY END VIEW DRAWING : FIG. 4.3

(b) Face length auto controlled.
(c) Gate to auto control start point.
(d) Gate to magnet.

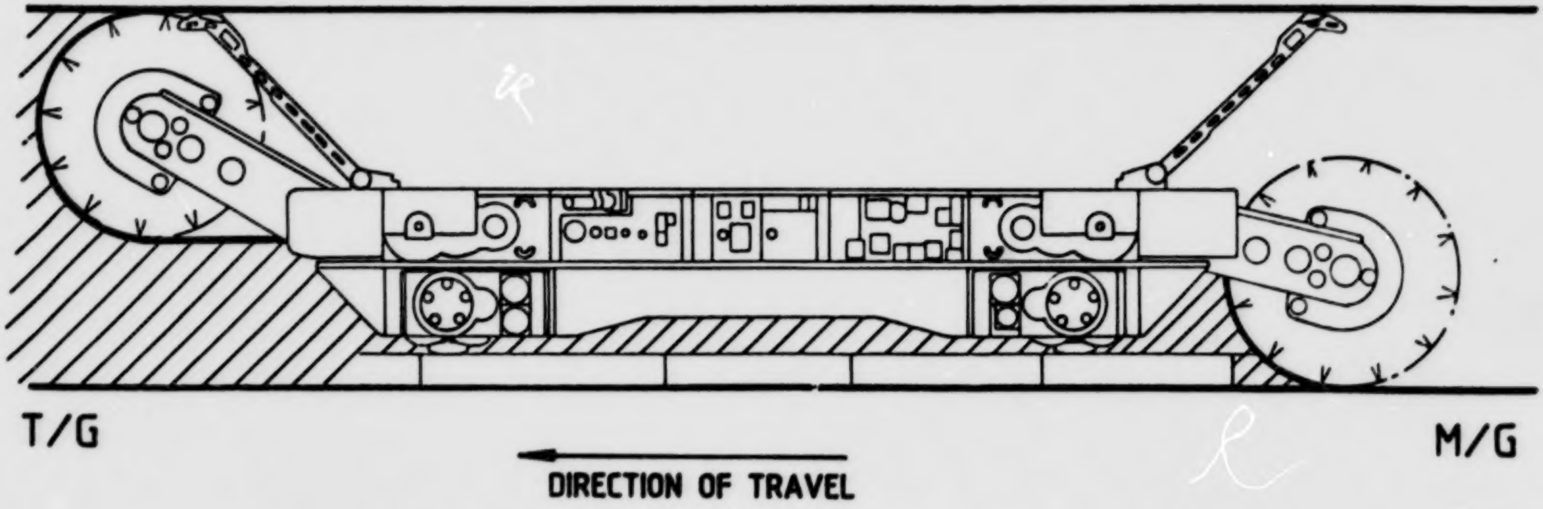

(b)
(c)
(d)
TAILGATE CENTRE LINE
MAINGATE CENTRE LINE

PERSONALITY DRAWING FOR TYPICAL FACE LAYOUT : FIG. 4.4


M/G
T/G
DIRECTION OF TRAVEL

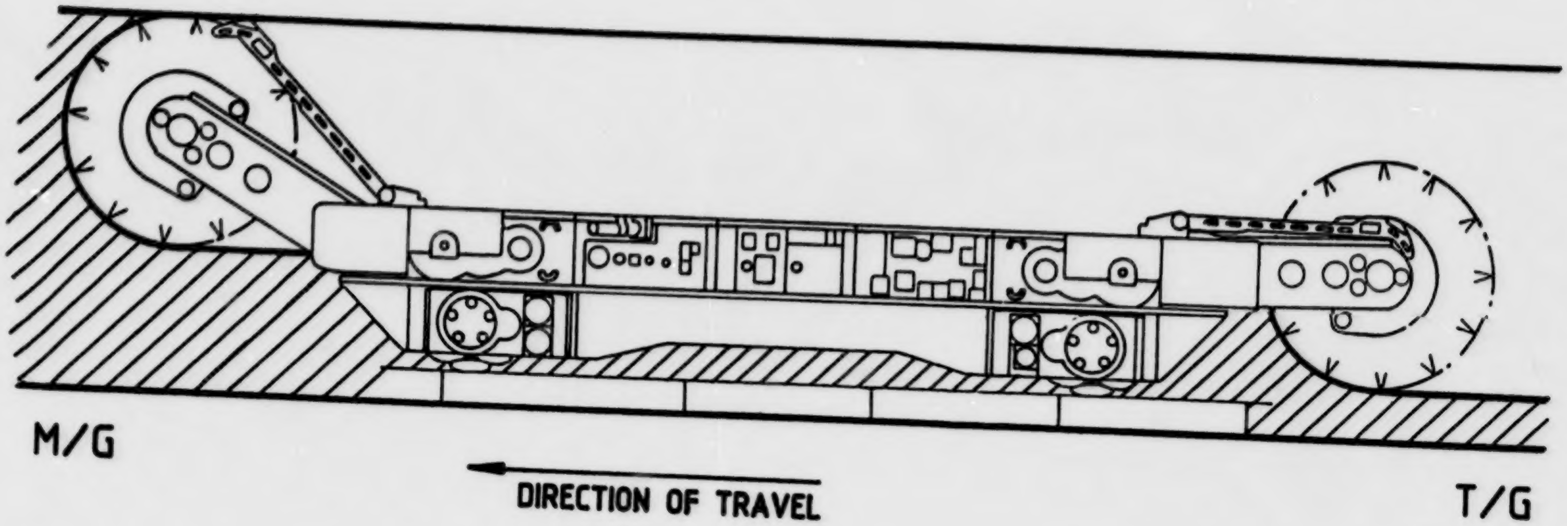
D.E.R.D.S. Single Pass Operation
Mining Method 13

FIG. 4.5


T/G
M/G
DIRECTION OF TRAVEL

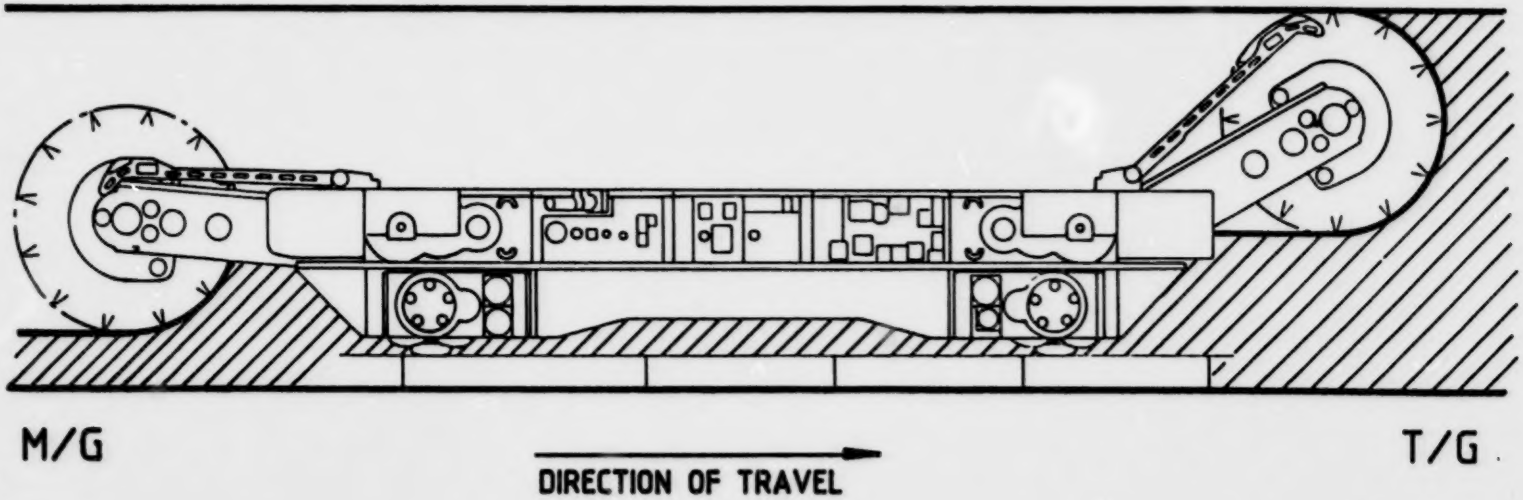
D.E.R.D.S. Single Pass Operation
Mining Method 14

FIG. 4.6


M/G
DIRECTION OF TRAVEL
T/G

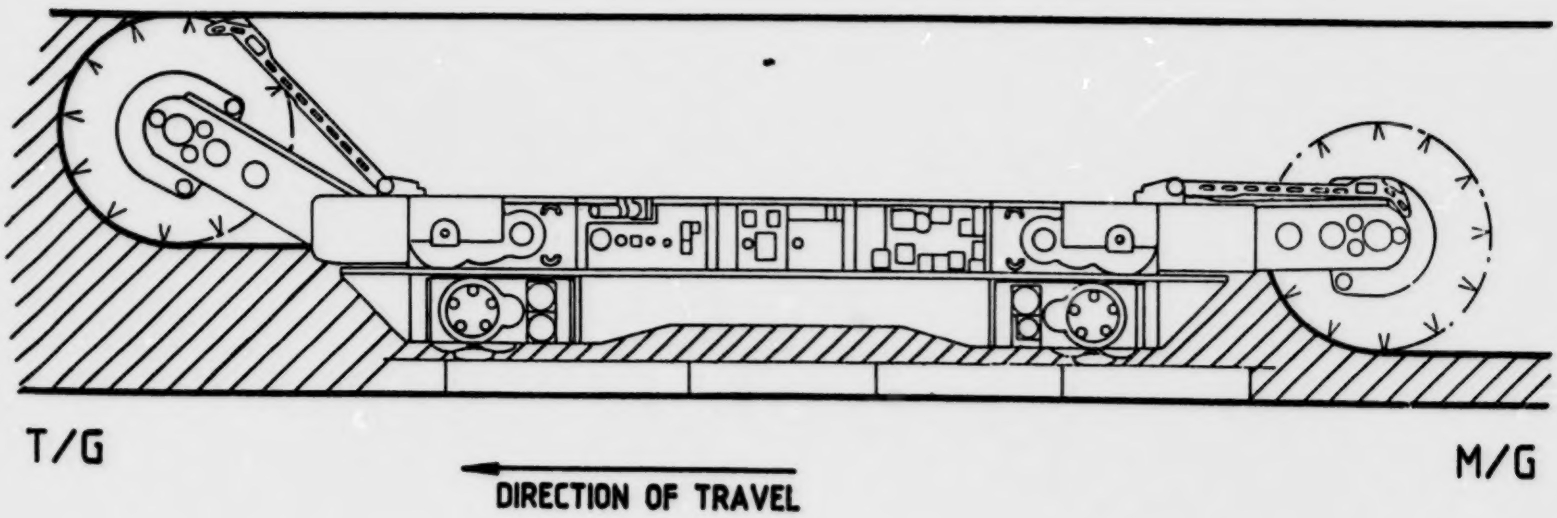
D.E.R.D.S. Double Pass Operation
Mining Method 19

FIG. 4.7


M/G
T/G
DIRECTION OF TRAVEL

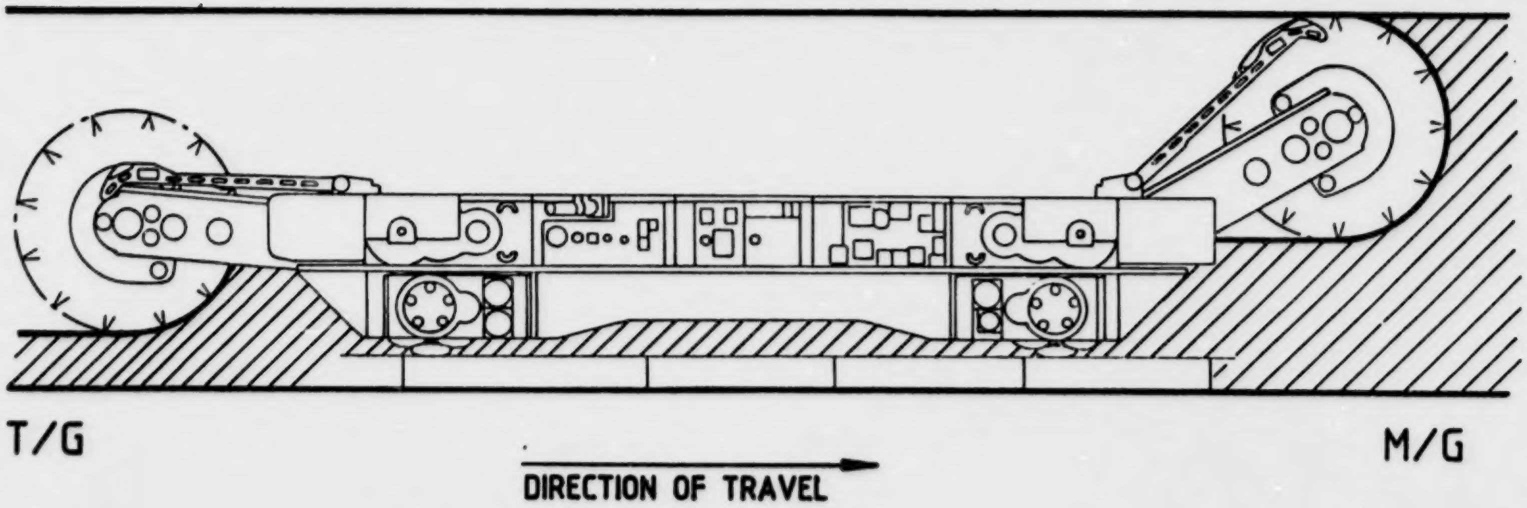
D.E.R.D.S. Double Pass Operation
Mining Method 20

FIG. 4.8


T/G
DIRECTION OF TRAVEL
M/G

D.E.R.D.S. Double Pass Operation
Mining Method 21

FIG. 4.9


T/G
M/G
DIRECTION OF TRAVEL

D.E.R.D.S. Double Pass Operation
Mining Method 22

FIG. 4.10

AUTO-STEERING WITH DIAM

CONTENTS

SECTION	DESCRIPTION
1	Introduction to the System
2	Description of Operation

INTRODUCTION TO THE SYSTEM

INTRODUCTION

The Mining Research and Development Establishment (MRDE) has been working on the automatic guidance of coal-winning machines for a number of years. Recent experience with proto-type systems on single-ended ranging drum shearers (SERDS) has shown that automatic guidance has the potential to increase productivity on the coalface, improve proceeds, facilitate more effective roof control and result in coalface equipment suffering less damage. Hence, great emphasis is being placed on the rapid exploitation of the development.

WHY DO WE NEED AUTOMATIC STEERING?

Consider the manual steering of a single-ended ranging drum bi-di shearer. The machine has to be steered by ranging the boom, on a fixed underframe. The operator must determine the optimum position of the boom in order to leave the correct thickness of roof coal, often without the aid of any visible marker bands. At the same time, he must take into consideration, not only the angle of the machine relative to face advance, but also look out for humps and swilleys along the face length. The operator must remember that excessive steps in the roof can cause problems when advancing chocks, and he is hampered by the fact that his steering actions are interrupted at every chock leg when he takes his hand off the valve handles. All of these steering elements are not easy to reconcile for optimum machine performance. We therefore have a need for an automatic steering system, the DIAM system.

WHAT IS DIAM?

DIAM is the name given to a set of specifically designed electronic equipment for use with ranging drum shearers. Its main objective is to obtain and then maintain the correct amount of roof coal while taking the necessary extraction thickness, i.e. to keep the machine on the required cutting horizon in the seam. This is achieved by the automatic control of boom movements in response to changes in face conditions, which would otherwise result in the correct horizon being lost.

In addition to the control equipment underground, there is a computer and associated equipment in the surface control room. The units receive information, which is sent continuously from the machine while it is switched on. This information is used to assess the performance of the automatic steering, to indicate the condition of the machine and to provide data regarding machine position along the face.

To summarise, the DIAM system provides:

1. Automatic Vertical Steering.

2. Maintenance Information.

3. Management Information.

HOW DOES THE DIAM SYSTEM WORK?

The central control module receives information about the surrounding environment from transducers and sensors mounted on the machine and makes decisions on the type of steering action required to maintain optimum mining conditions. Once these decisions have been made, control demands are issued to initiate boom movements.

The DIAM unit requires:

a) Reliable and accurate determination of roof coal thickness continuously along the face (provided by the Natural Radiation Sensor);

b) Measurement of machine angle, relative to seam angle, in the direction of face advance (provided by the Tilt Transducer);

c) Determination of the vertical position of the drum, relative to the previous cut (provided by the Roof Height Transducer);

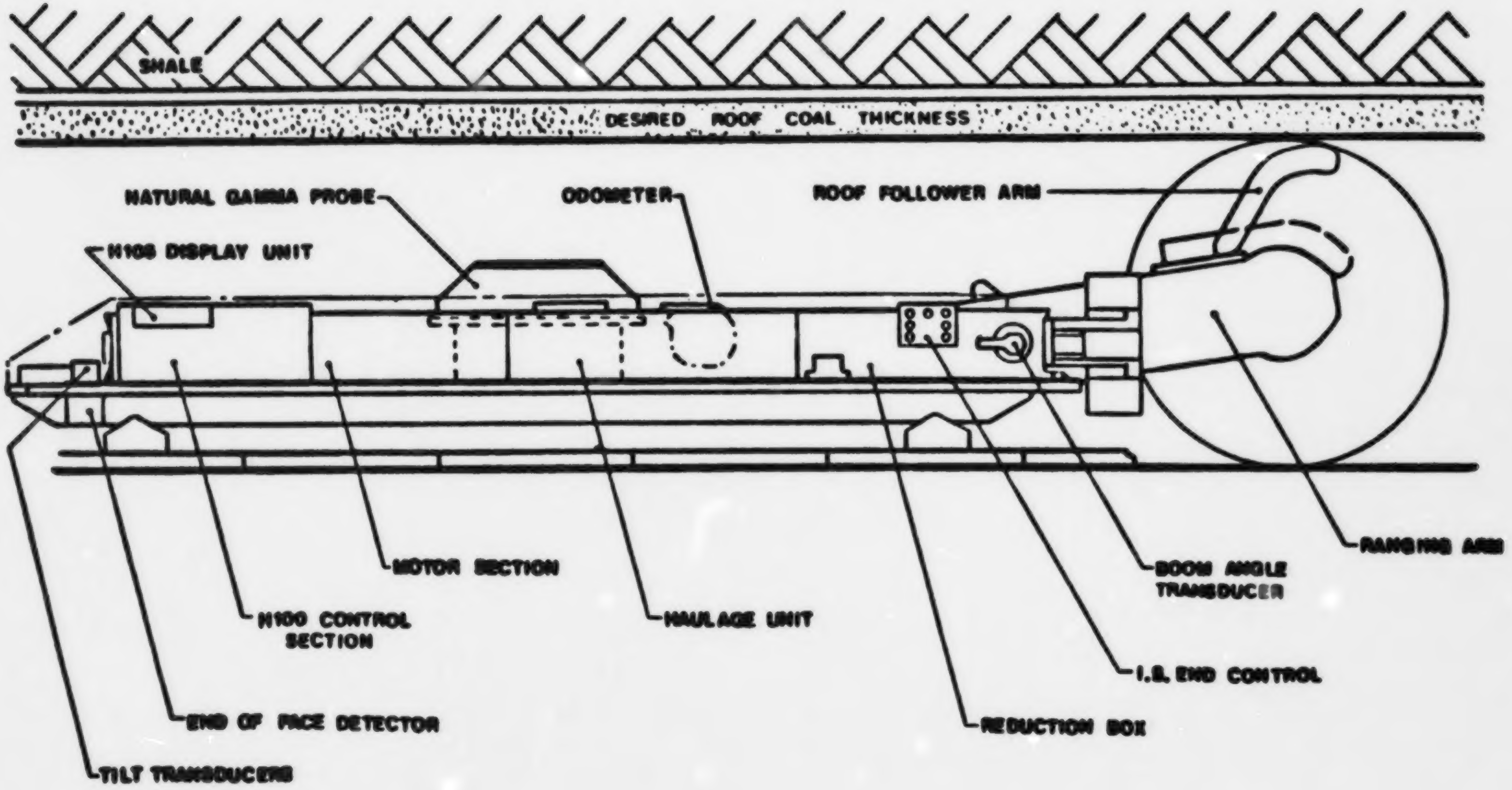
d) In two-pass mining, measurement of the actual coal extraction (provided by the Boom Angle Transducer);

e) Indication of the machine direction of travel and position along the face (provided by the odometer).

f) Identification of the main gate end of the face (provided by End of Face Detector); and,

g) Confirmation of direction of machine movement (provided by Haulage Direction Pressure Transducers).

All these sensors and transducers are mounted on the machine and are shown in Figure 1.


SHALE
DESIRED ROOF COAL THICKNESS
NATURAL GAMMA PROBE
ODOMETER
ROOF FOLLOWER ARM
H108 DISPLAY UNIT
MOTOR SECTION
HAULAGE UNIT
RANGING ARM
BOOM ANGLE TRANSDUCER
H100 CONTROL SECTION
I.S. END CONTROL
END OF FACE DETECTOR
REDUCTION BOX
TILT TRANSDUCERS

DIAM

FULL EXTRACTION EXAMPLE fig.1

CONTROL TRANSDUCERS

In this section, the transducers under consideration are those directly involved with the automatic steering of the machine. Other transducers used on the machine, i.e. flow, pressure and temperature are known as 'condition transducers'.

Natural Radiation - Coal Thickness Transducer

It has been found that most roof shales in coalmining, contain a measureable amount of radioactivity. Coal, due to its density, will act as an absorber of the radiation from the overlying shale. The degree of absorption will increase as the thickness of coal increases.

Therefore, if we mount a radiation sensor on the coal-cutting machine, so that the sensor has a clear view of the roof, the amount of radiation it receives will be (approx.) inversely proportional to the thickness of roof coal, i.e. the thinner the roof coal, the higher the receipt rate. The sensor converts the receipt rate into an electrical signal which is then translated into an actual coal thickness reading (in mm) by the DIAM unit.

Tilt Transducers

There are two tilt transducers in the system, to measure:

a) Face Advance Tilt (FAT) angle, i.e. the angle of the machine, relative to the seam inclination, in the direction of face advance; and

b) Along Face Tilt (AFT) angle i.e. the angle of the machine, relative to the seam inclination along the face (used only for monitoring face contour variations).

Both transducers are contained in steel boxes bolted to the machine underframe.

A tilt transducer consists of a curved, linear potentiometer whose operating slider is fitted to a free-moving pendulum. As the assembly is tilted, the pendulum keeps its vertical position while the slider moves across the potentiometer by an amount proportional to the angle of tilt. With this arrangement, it is possible to provide a steady voltage, proportional to the angle of tilt from any given reference. This output is converted into degrees positive (+ve) or negative (-ve), relative to the seam angle reference by the DIAM unit.

Mechanical Roof Height Transducer (MRHT)

The function of this transducer is to provide an electrical signal proportional to the vertical displacement of the roof follower arm.

The transducer itself is mounted at the pivot of the hydraulically operated, heavy duty arm, located at the drum end of the boom. The arm rubs the roof of the previous cut. The electrial signal produced provides the DIAM unit with the reference around which all the steering demands are based e.g. if the roof coal thickness sensor and tilt transducer indicate that the boom requires raising by 15mm, then this movement is made relative to the roof follower position. All steps are normally limited to a maximum of +40mm to maintain good mining conditions.

Boom Height Transducer

When used on a two-pass system, during the floor cut, the DIAM unit cannot use the signals from the MRHT to base its steering demands on, since the MRHT is no longer in contact with the roof. In this case, the necessary reference is provided by the Boom Height Transducer (BHT).

This transducer consists of a potentiometer driven by the boom shaft; the electrical signal produced being proportional to the angular position of the boom, from this angle the central control module calculates the vertical position of the drum.

As the shearer passes on its roof cut, the BHT readings are taken at intervals and remembered by the DIAM unit. On the return floor cut, these readings are used by the DIAM unit at the correct points, to control the boom movement. The floor cut is thus an exact mimic of the roof cut.

Odometer

The function of this transucer is to detect movement of the machine in either direction and also to provide information to allow the machine position along the face to be monitored. The Odometer is contained in a mild steel enclosure and can be sited in a variety of positions, where it is most convenient to pick up the machine drive, e.g. a spare output shaft, haulage pinwheel etc.

End of Face Detector

If for some reason, such as a broken machine haulage chain, the drive to the Odometer unit is turned without the machine being moved, an erroneous 'along face' position can be indicated i.e. the count, as registered by the Odometer unit, does not relate to the actual machine position. This false value is reset by the useof a face end detector which is incorporated in the face conveyor pan line near to the gate-end.

The detector itself is in two parts:

a) a stainless steel casting, housing a permanent magnet bolted to the conveyor pan furnishings; and

b) A magnetically-operated switch, housed on the machine underframe in such a manner as to pass within 40mm of the conveyor-mounted magent as the machine goes by.

The magnet is usually positioned within 10mm of the centre line of the gate. As the magnet is passed, the machine-mounted switch is operated, signalling to the DIAM unit that the machine is now at a known position. Any errors in the Odometer counter are then corrected.

Haulage Direction Pressure Transducers

These Pressure Transducers monitor the main haulage pressure in both directions of along face travel. They are used to check the direction of machine movement.

THE PROCESS OF AUTOMATIC STEERING

Full Automatic Control

It must be remembered that the machine is to be steered by ranging the boom, rather than tilting the underframe. Therefore, when a deviation in tilt or roof coal thickness is being corrected, a step will be put in the roof between the previous and present cuts. The system measures roof coal thickness in the previous cut, together with face advance tilt and determines from these factors the size of step, if any, which is required in the roof to ensure minimum mining problems. The step is generally limited to a maximum of 40MM, up or down.

Examples of Steering Action Taken

1. In Figure 5, the roof coal thickness is as required and the tilt of the machine in face advance is equal to the seam angle in that direction. The system, having measured this, calculates that the step in the roof should be zero and, consequently, steers the drum to maintain this condition.

2. On the next machine pass, following the above example, the machine comes to a place along the face where the conveyor has been pushed-over on coal fines. This has caused the pans (and therefore, SERDS), to tilt up at an angle of 4 degrees. The system, having measured the correct roof coal thickness in the previous cut, now registers the upward tilt of the pans and calculates that if no steering action is taken, then the new roof coal will become too thin.

   Consequently, the boom is activated to put a downward step in the roof, which is calculated to correct the tilt of the pans whilst maintaining an adequate roof thickness (see Figure 6). After such disturbance, it will take a number of passes to get the machine back on true cutting horizon, thus ensuring a smooth roof and floor profile.

3. If the tilt of the pans is correct but the roof coal thickness is far too great, the boom will be automatically raised to rectify the situation (see Figure 7). Operational difficulties may occur if the step put in the roof is too large. The size of the step is, therefore, limited to 40mm.

4. When both the roof coal thickness and upward angle of the pans are much larger than the desired values, the system will try to correct both gradually, while limiting the step in the roof, so that operational difficulties are not caused. As shown in Figure 8, there will be a step-down cut in the roof, although the roof coal is already far too thick. This is one in order to prevent the pan angle (and machine) getting out of control.

5. When the roof coal thickness is as required, and the pans are tilting downward, a 'step-up' will be made in the roof, as Figure 9 shows.

HOW WELL DOES THE SYSTEM STEER?

1. Face Advance Angles

The angle of the AFC pans is influenced by floor lift and clean-up, as well as the steering action of the system. These angles are visible in the roof. The maximum steering correction i.e. step-up or step-down is increased to 65mm on any one machine pass along the face, in the case of excessive machine tilts i.e. a deviation of machine angle from seam angle greater than 4 degrees.

2. Steering Rates

The boom ranging speeds are much higher than on standard SERDS, and this should be kept in mind when ranging the boom manually. The high ranging rates are required in order to allow the system to cope with machine speed of up to 25 ft/min. when negotiating angles between pans of up to 7 degrees. Ideally, these angles should be 4 degrees maximum but due to wear and tear of AFC pan joints, as much as 7 degrees may be reached.

3. Roof Coal Thickness

The maximum range of roof coal thickness that the system can deal with is 0 to 460mm. (0 to 18").

4. Automatic Steering - Face Length

The length of coalface, over which the machine can be automatically controlled, is governed by the method of working. There is no restriction on face length up to a maximum of 300m.

SURFACE MONITORING

The required information is collected at the machine and sent to the surface by the DIAM data transmission system, where it is stored in the memory banks of a mini-computer. The data thus obtained may be assessed and displayed on the screen of a visual display unit (VDU), in either a graphic or numeric format. Hard copies of this information may be made automatically, if required. This facility for monitoring the control equipment has been extended to include certain temperatures, hydraulic pressures and flow rates of the machine's equipment. As additional techniques become available, other features such as hydraulic fluid and gearbox oil condition, machine cutting speed and vibration will also be monitored. The high computing power and ease of software changes have shown that, in the longer term (apart from immediate fault detection and display, which must be carried out at the machine), general monitoring is best performed at the surface.

Examples of some of the current graphic displays available are shown in Figures 2 - 4. A large amount of other data is available and will generally be used for diagnostics; this may be displayed and copied when required.

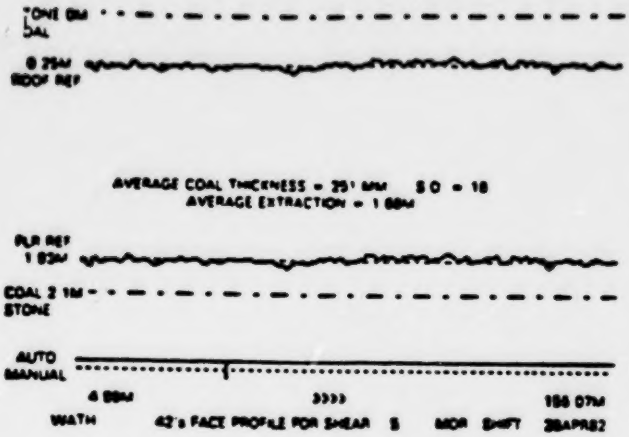
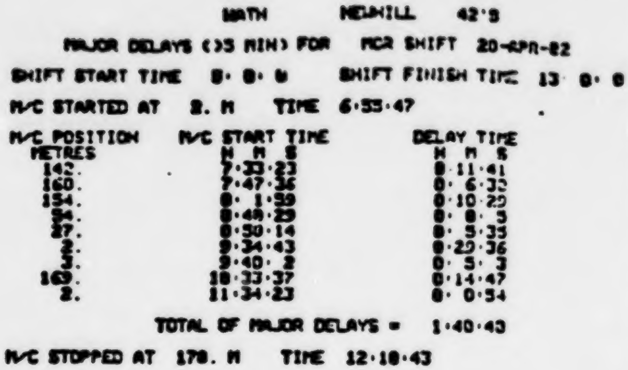


FIGURE 2



```
                    WATH        NEWHILL    42'S
      MAJOR DELAYS (>5 MIN) FOR   MOR SHIFT  28-APR-82
SHIFT START TIME   8: 0: 0      SHIFT FINISH TIME  13: 0: 0
M/C STARTED AT   2. M    TIME  6:55:47
M/C POSITION    M/C START TIME             DELAY TIME
  METRES            H  M  S                  H  M  S
   142.             7:33:23                  0:11:41
   160.             7:47:36                  0: 6:33
   154.             8: 1:59                  0:10:29
    96.             8:48:29                  0: 8: 5
    27.             8:50:14                  0: 5:35
     2.             9:34:43                  0:29:36
     3.             9:40: 2                  0: 5: 3
   163.            10:33:37                  0:14:47
     2.            11:34:23                  0: 0:54
             TOTAL OF MAJOR DELAYS =      1:40:43
M/C STOPPED AT  170. M    TIME  12:18:43
```

FIGURE 3

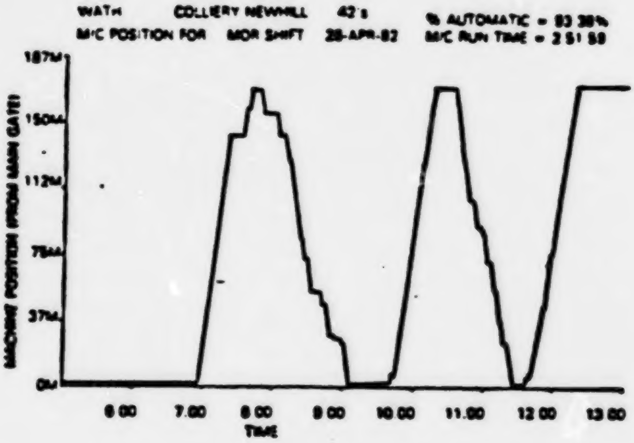


FIGURE 4

STEERING ACTION

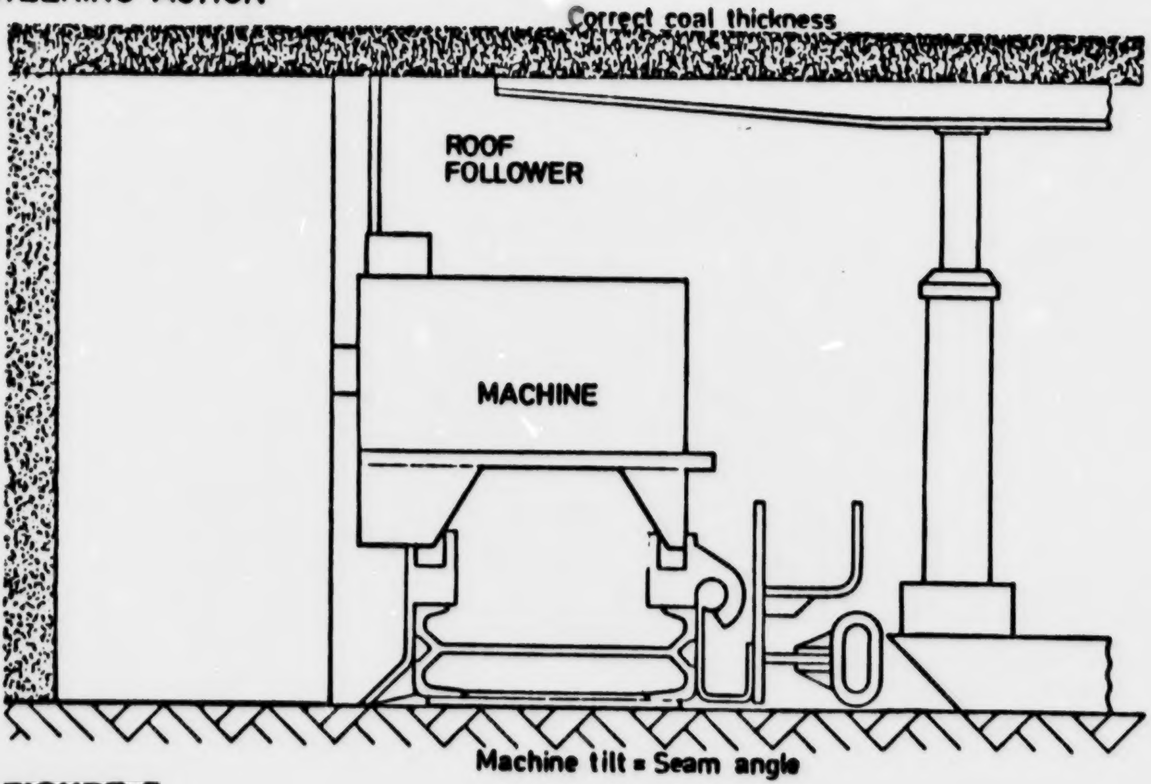
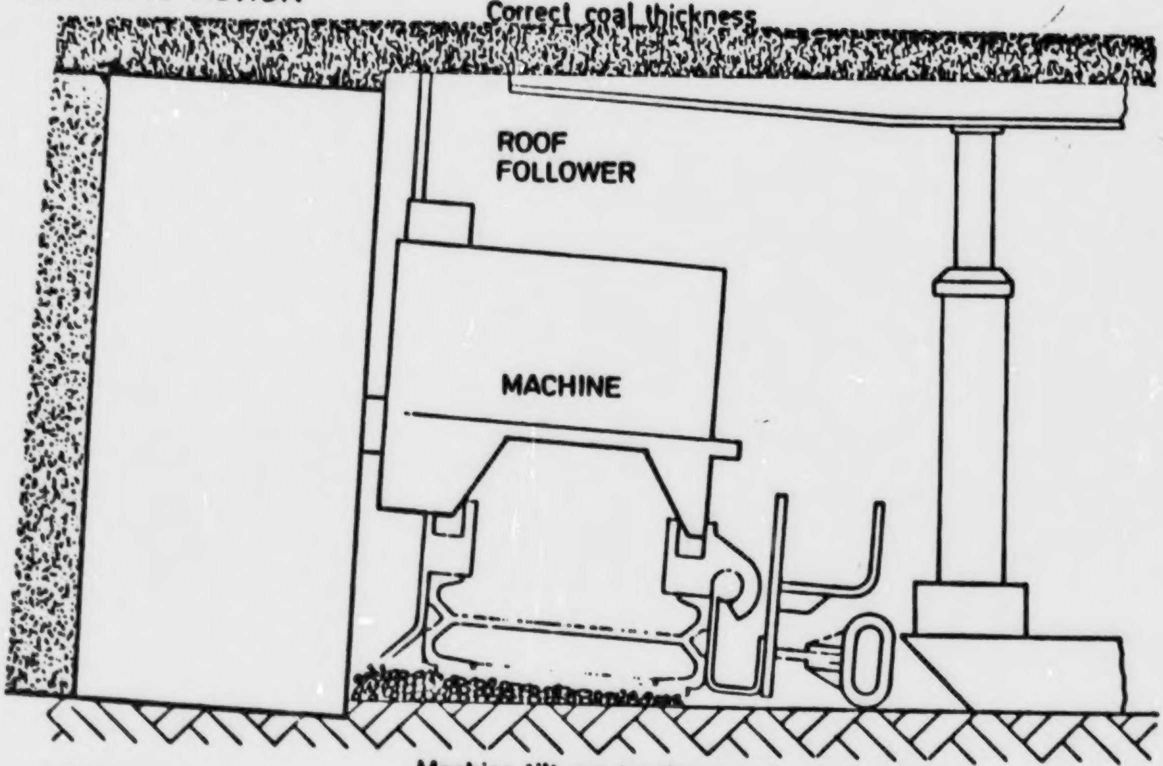

Correct coal thickness
ROOF FOLLOWER
MACHINE
Machine tilt = Seam angle

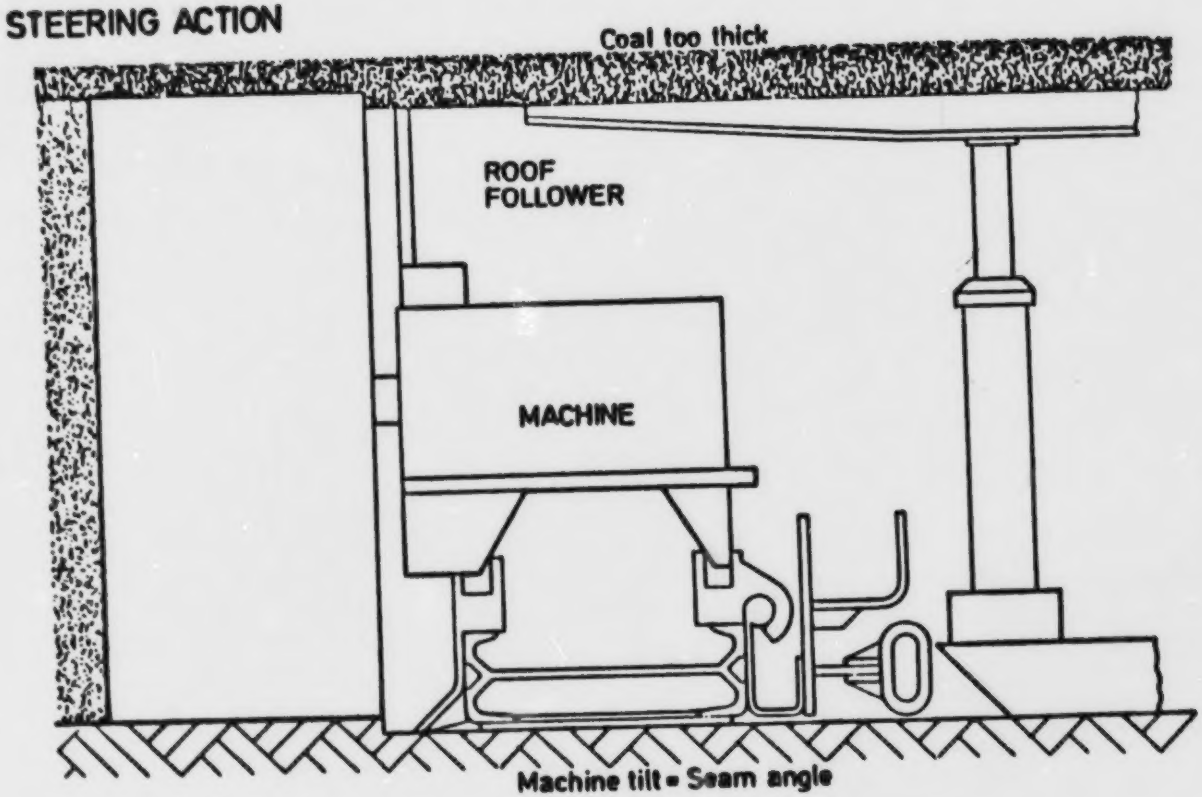
FIGURE 5

STEERING ACTION


Correct coal thickness
ROOF
FOLLOWER
MACHINE

Machine tilt greater than seam angle +ve

FIGURE 6


STEERING ACTION

Coal too thick
ROOF FOLLOWER
MACHINE
Machine tilt = Seam angle

FIGURE 7

STEERING ACTION

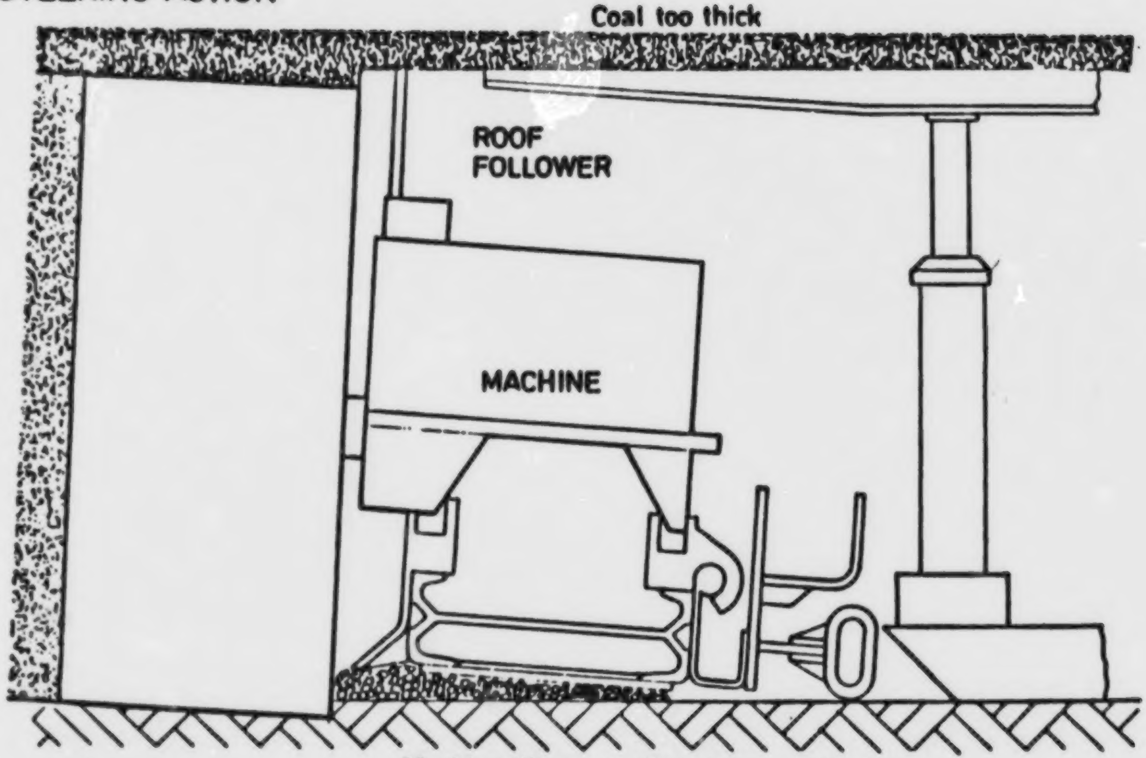

Coal too thick
ROOF FOLLOWER
MACHINE

FIGURE 8

Machine tilt greater than seam angle +ve

STEERING ACTION

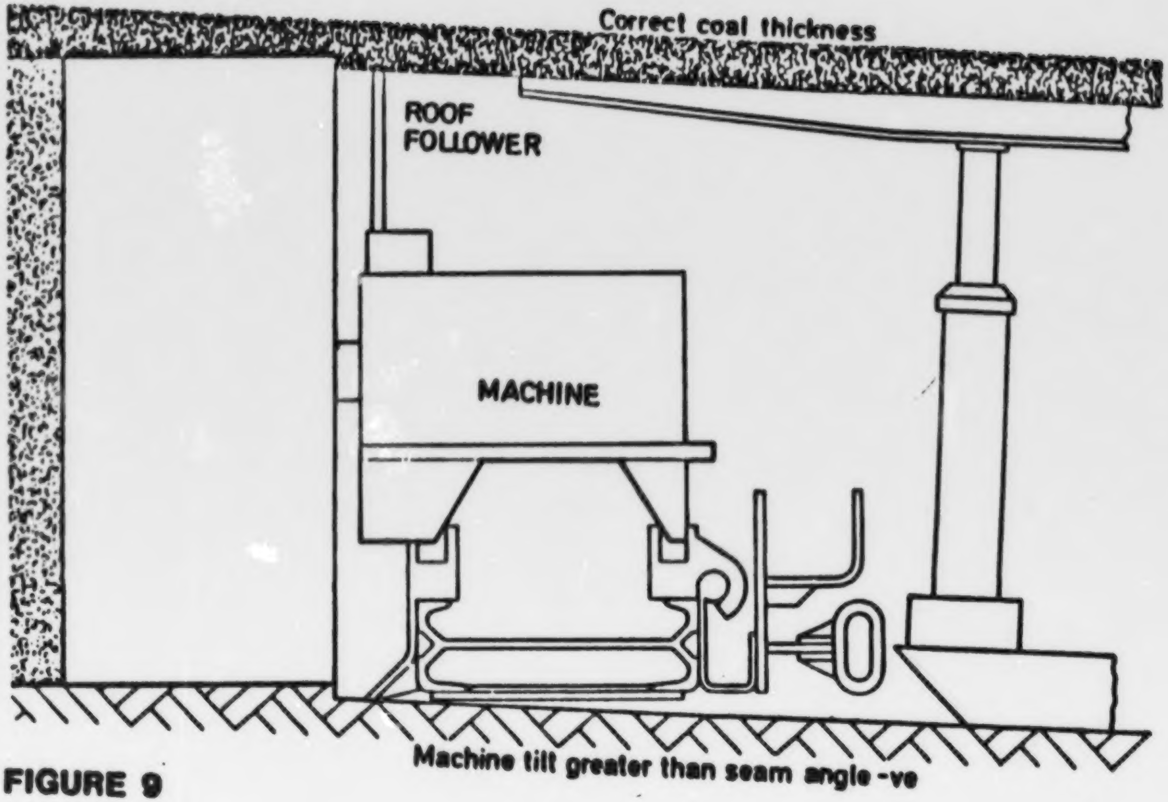

Correct coal thickness
ROOF
FOLLOWER
MACHINE
Machine tilt greater than seam angle -ve

FIGURE 9

GLOSSARY OF TERMS

This is a glossary of terms which you may come across during your work with the DIAM system.

TERM	DEFINITION
AFT	The Along Face Tilt transducer measures the angle of the machine along the line of face relative to level.
ALPHANUMERIC	A display made up of letters and numbers.
AUTO DEFEAT SWITCH (MODE SWITCH)	A DIAM controlled machines' normal mode of operation is under Automatic control. This switch is used to defeat Automatic control.
BOOM ANGLE TRANSDUCER	The transducer which measures the angle of the ranging arm.
COMMISSIONING PROCEDURE	Procedure to be followed on the DIAM unit when installing new or replacement units to the machine.
DEAD BAND	The amount of movement of the roof follower, each side of the actual ranging arm position, where no steering action takes place. This +/- 10mm. During commissioning this is 4/-5mm.

DEGRADED AUTOMATIC CONTROL	The mode of Automatic Control when the coal thickness signal is NOT available.
END OF FACE DETECTOR	Device to set (or reset) the along face machine position to a known value at a fixed point.
FAT	The Face Advance Tilt transducer measures the angle of the machine relative to the seam angle in line of advance (or retreat) of the face.
FULL AUTOMATIC CONTROL	Any mode of Automatic Control where a qualified coal thickness signal is used.
LOOP	Computer terminology; a series of instructions which are performed repeatedly until some specified condition is satisfied.
MULTIPLEXER	A device that marshalls several signals to be transmitted serially over one pair of wires.
ROOF COAL THICKNESS SENSOR	Device that measures the natural gamma emission from the strata above the coal seam, sometimes referred to as 801/802 natural gamma sensor.
PARAMETER	A measurable dimension.

POTENTIOMETER	A device for measuring differences in electrical potential used for position indication.
ROOF FOLLOWER	The transducer which measures the step between the previous roof cut and the present roof cut.
SENSOR	Device giving a signal for measurement or detection of a physical property to which it responds.
SERVO	Means of Automatic Control of a larger system.
SETTLING TIME	The time required after switching on the machine or a transducer to allow transient values to pass.
SOFTWARE	A computer programme.
TRANSDUCER	Device that converts variations of one quantity into those of another e.g. pressure to voltage.
USER FRIENDLY	Computer term meaning easy to use.

DESCRIPTION OF OPERATION

D.I.A.M. SINGLE PASS S.E.R.D.S.

INTRODUCTION

This description of operation covers a D.I.A.M. Automatically Steered S.E.R.D.S. suitable for BI/DI single pass operation i.e. taking the full extraction in both directions of machine travel. The machine under consideration is a B59C maximatic with R10 hydraulic haulage and F34B 200 H.P. Electric Motor.

The first difference between the D.I.A.M. machine and a standard shearer is in the procedure required for starting. The start and stop buttons are located on the door of the H100 control section. This machine is fitted with an H109 P.O.I.S. unit (see Pilot Circuit Section for details), which has a relay contact in the 'start' section of the Pilot Circuit. The timing of the closing and subsequent re-opening of this contact is designed to be compatible with both P130 and BZ1 type Pilot Circuits. The control system of the machine includes a 'watchdog' relay in the Pilot Circuit. This is a normally open contact held closed while ever the system is running normally. This contact must be shorted out on start up until the system has completed integrity checks and energised the watchdog relay. This is done by means of an extra contact on the start switch. At start up the start button must be kept depressed until the system has completed its integrity check. In practise, this means keeping the button depressed until the 'green' H69 running lamp behind the window in the door of the H100 control section begins to flash (Figure 1). After starting, control over direction of machine travel and speed of machine movement is done in the same way as with a standard shearer, using the speed control knob on the F34B motor.

The normal mode of operation of this machine is 'auto', (Figure 2). In this mode the system will control the machine while the auto controlled area of the face, and initiate in taking control from or passing it back to, the operator at the relevant points.

Outside of the auto controlled area the operator has control of boom and cowl movement by means of push buttons on the H73/2 I.S. End Control Station. The red 'mode' lamp will be lit, indicating that the operator has control. When the machine gets to the start of the auto controlled area the roof follower arm will raise automatically. The red and green mode lamps will flash alternately, indicating that there is to be a change in control. The operator must acknowledge that the system is to have control over boom movement by pressing the 'control select' button on the H73/2. The red mode lamp will go out and the green mode lamp will be steady to indicate that the movement of the boom is now under 'auto control'. Control of cowl movement is still done by the operator by means of the push buttons on the H73/2.

If the operator does not acknowledge the change of control within a preset time, the system will initiate a haulage stop. This can be cleared by the operator pressing the control select push button and re-selecting haulage speed in the normal manner.

At the end of the auto controlled area, the changeover is reversed. The roof follower will automatically be lowered to its 'park' position. The red and green mode lamps will flash alternately. The operator must press the 'control select' button as before, within a preset time. The green lamp will go out and the red lamp will be steady, indicating that the operator has control over boom movement by means of the H73/2 push buttons.

If a fault occurs during the auto run, which would prevent auto steering, i.e. a control transducer sustains damage or goes outside its preset range, the system will initiate a haulage stop and indicate that the operator should take control. A fault message will be displayed on the D.A.D.U. The fact that the system has initiated the haulage stop will be indicated by a flashing red 'haulage inhibit' lamp on the H73/2. The operator can continue to drive the machine by selecting 'auto defeat'. The fault must be cleared before the machine can continue in auto.

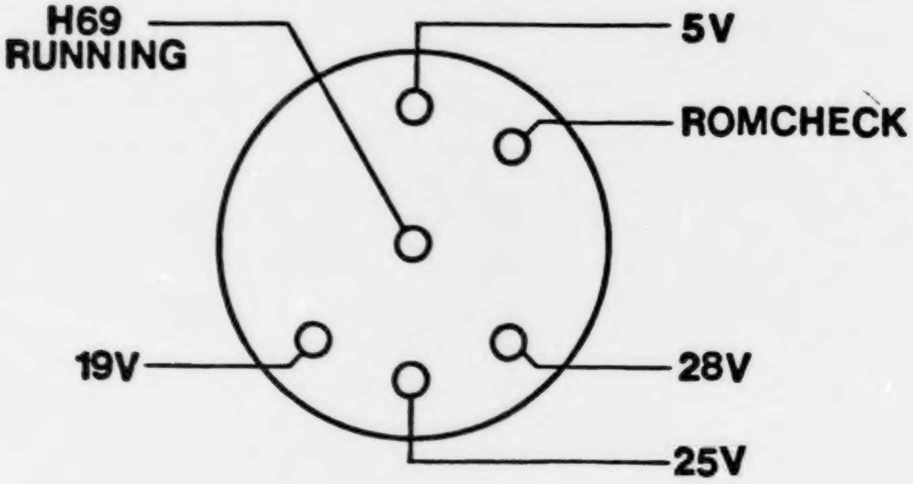
If for any reason the system is not steering correctly, or is unable to steer due to damage etc., it can be overridden by selecting auto defeat at the mode switch. With the mode switch in this position, the operator has control over the boom and cowl via the H73/2 push buttons at all times. The haulage stop button on the H73/2 is still operative.

If the system fails, for whatever reason, and the operator cannot reliably control the boom from the H73/2, then a 'manual' position is available on the mode switch. With the mode switch in this position, oil is piverted to the manual valves on the B59.

The watchdog and haulage stop relays are shorted out and power taken off the solenoid drives so that the H73/2 push buttons have no effect on the machine. Operation of the machine in this mode is like that of a normal shearer.

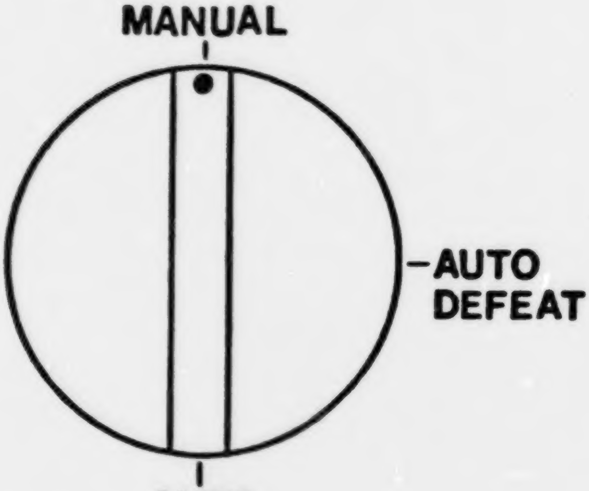
DIAM L.E.D.S

fig.1


H69
RUNNING
5V
ROMCHECK
19V
28V
25V

DIAM MODE SWITCH

fig.2


MANUAL
AUTO
DEFEAT
AUTO

D.I.A.M. CONTROLS ON H100

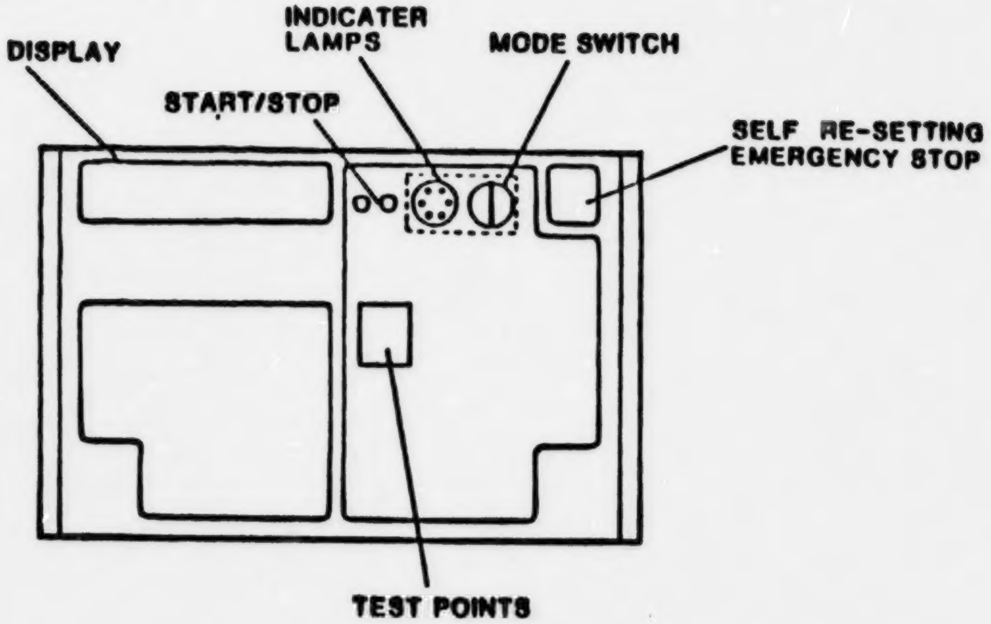
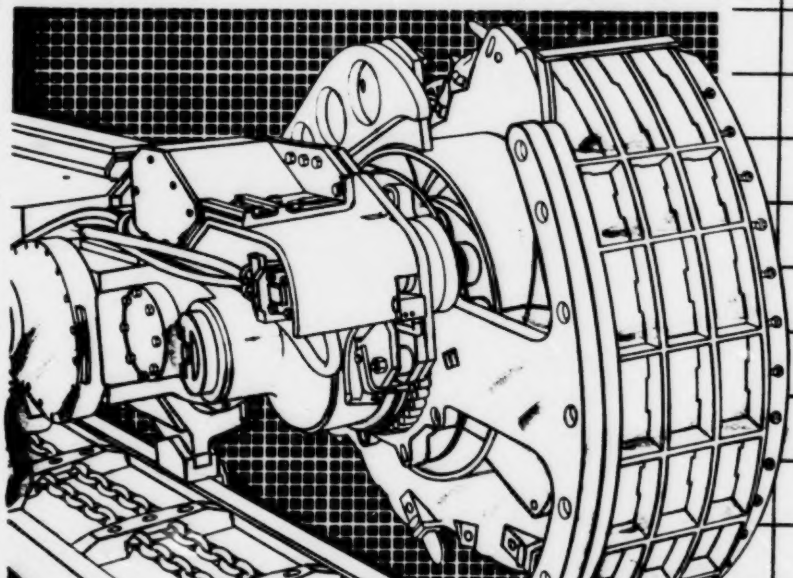
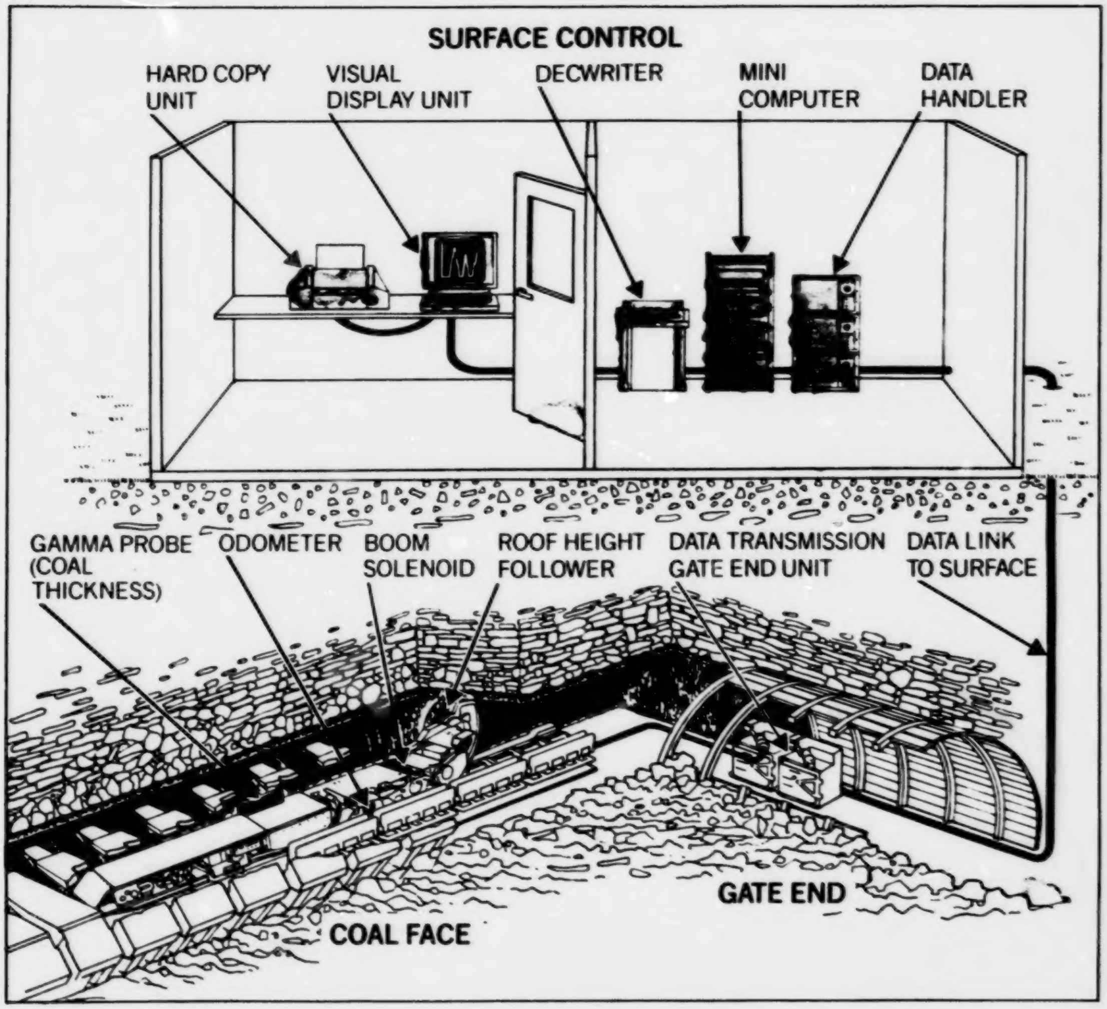

DISPLAY
START/STOP
INDICATER LAMPS
MODE SWITCH
SELF RE-SETTING EMERGENCY STOP
TEST POINTS

fig. 3



IMS


SURFACE CONTROL
HARD COPY UNIT
VISUAL DISPLAY UNIT
DECWRITER
MINI COMPUTER
DATA HANDLER
GAMMA PROBE (COAL THICKNESS)
ODOMETER
BOOM SOLENOID
ROOF HEIGHT FOLLOWER
DATA TRANSMISSION GATE END UNIT
DATA LINK TO SURFACE
GATE END
COAL FACE

PATHFINDER

THE NEW HORIZON IN MACHINE STEERING

Automatic machine steering has been available in various forms since the early 1980s and the benefits of increased productivity, quality of product and superior face conditions are well established and proven.

Mining Supplies (Longwall) Ltd has now produced a radical new, intrinsically safe, system which is capable of delivering these benefits without the complexity and cost which up to now have normally been associated with machine steering systems.

Pathfinder has been specifically designed to be simple to operate without the need for additional machine sections—resulting in a cost-effective modular system which can be applied to any make of single ended ranging drum shearer as a retrofit package.

GENERAL DESCRIPTION

Pathfinder was developed in conjunction with British Coal specifically to produce a simple, cost effective machine steering system—together we've succeeded!

Pathfinder is based on techniques established by Headquarters' Technical Department which have been developed to produce a system quite unlike any other system available today.

Standard Machine steering transducers are used to provide signals which will allow the systems' Steering Control Unit to maintain the optimum horizon when cutting.

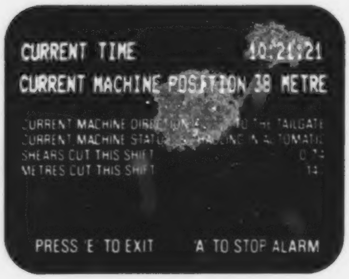
Power for the system is provided by the power take-off unit which interrupts the trailing cable prior to connection to the machine. This simple but radical innovation allows IS power to be supplied to the system without the need for cross certification and is the only FLP unit in the whole system. Additional expensive flameproof machine sections are not therefore required and full compatibility with any machine is guaranteed.

Operator control panels with their unique 'self illuminating display' can be provided at one or both ends of the machine and allow for manual control of the drum position together with a readout of machine performance data.

During automatic cutting the most important parameter to measure is the step between the present and previously cut roof. This is carried out by the roof follower transducer which tracks along the previous cut sending datum reference signals to the steering control unit. Any deviation between the present and last machine cut is corrected by automatic adjustment of the ranging arm, which ensures that the drum follows the contour of the previously cut roof. The amount of coal left at the roof (measured by the Natural Gamma Probe) together with the angle of the machine drum in relation to the seam angle in line of face advance, are also taken into account, ensuring the machine stays on horizon at all times.

Information received from the various transducers processed by the Steering Control Unit is not only used to guide the machine but can be transmitted to the surface to provide vital management information.

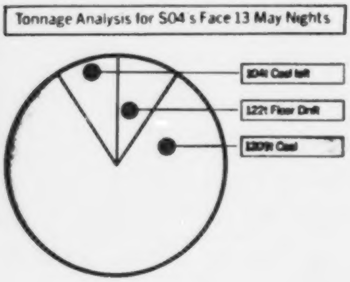
This information is available at the surface in both graphical and report form including for example, production rates, utilisation of machine available time, number of strips per shift etc.

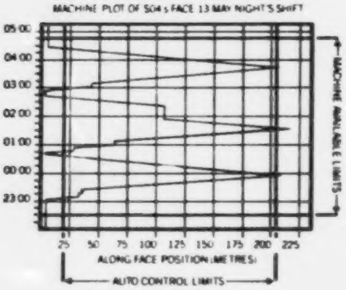


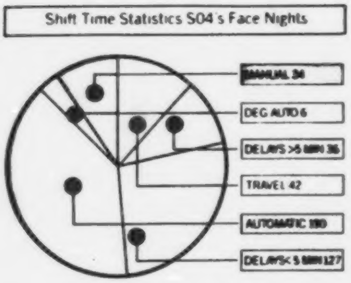
CURRENT TIME 10:21:21
CURRENT MACHINE POSITION 38 METRE

CURRENT MACHINE DIRECTION [illegible] TO THE TAILGATE
CURRENT MACHINE STATUS [illegible] MACHINE IN AUTOMATIC
SHEARS CUT THIS SHIFT 0.74
METRES CUT THIS SHIFT 14

PRESS 'E' TO EXIT 'A' TO STOP ALARM







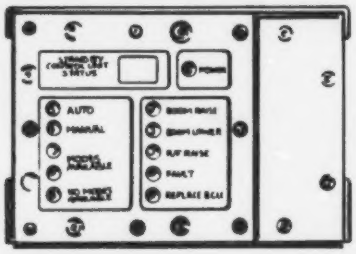
STEERING CONTROL UNIT (SCU)

The SCU is an intrinsically safe microprocessor based computer and is the 'brain' of the system. Under software control, the SCU scans several transducers:

Roof Height Follower—measures the step in the roof.
Boom Height Transducer—measures the angle of the ranging arm.
Tilt Transducer—measures machine tilt into the face.
Gamma Probe—measures coal thickness at roof.
Odometer—measures along face position.
End of Face Detector—provides a reference point for the odometer.
Haulage Direction Transducer—indicates haulage direction.

The SCU processes this information ten times every second and, if required, corrects the position of the ranging arm via an externally mounted intrinsically safe solenoid valve.

In addition the SCU carries out many other tasks simultaneously, for instance, off machine data transmission and cable checking.



POWER TAKE OFF UNIT (PTO)

The PTO is an FLP unit which typically is located at the end of the underframe extension. The PTO serves three main purposes:

1. It provides IS power for the steering system.
   1 x 7.5 V 1.4A
   2 x 12V 0.5A (one spare)
2. It provides start/stop facilities for the machine:
   All current pilot circuits supported
   POIS for P130 type circuits
   Single push-button start
   Self resetting emergency stop
   External connection to pre-start warning equipment
   Pilot interface relays
3. It houses the data transmission interface which allows off machine monitoring.
   System 70000 data transmission
   Pilot core system with any pilot circuit
   Type 7 or Type 7S cable

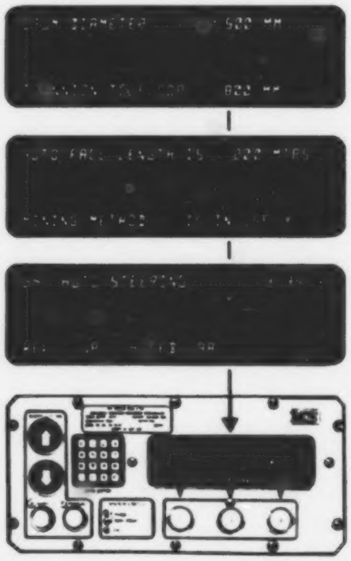
The incoming trailing cable is connected to the rear of the PTO through a restrained plug and socket. Power is obtained by tapping two phases. All three power phases and pilot core(s) loop directly out of the PTO through a gland or restrained plug and socket. A short length of cable connects power to the machine's original socket. This arrangement allows universal application to any manufacturer's machine.

OPERATOR PANEL (OP)

The OP is an intrinsically safe microprocessor based display unit. It is the means by which the machine operator can control the system. An alphanumeric fluorescent display provides information which is easily read from very wide angles. Push buttons allow the operator to:

a) select manual or automatic control
b) range the arm
c) select many different items of information

A keypad allows authorised personnel to alter a host of programmable variables (eg the required coal thickness to be left at the roof). The system can therefore be 'fine-tuned' on the job.



INTRINSICALLY SAFE SYSTEM

Allows easy maintenance even when powered. Expensive flameproof machine sections are not required which reduces the cost of the system.

FULLY COMPATIBLE

The system feeds off the machine trailing cable which is interrupted before entering the machine. Therefore, the system does not have to be electrically cross certified with the shearer, thus allowing it to be used with ANY make of single ended ranging drum shearer.

RETROFIT PACKAGE

The system is supplied as a set of modules rather than a machine section and can therefore be easily configured and applied to any given machine, (even underground) allowing automatic steering to be fitted at any stage during the life of a face.

OFF MACHINE DATA TRANSMISSION

When coupled with a data transmission system, information from the coal face is fed via a high speed data link to the surface supervisory system. Displays are available which indicate cutting efficiency, production rates and utilisation of machine available time, along with engineering information indicating the health of the systems.

BETTER DIRT MANAGEMENT

The system guarantees that the cutting drum remains on horizon and does not deviate, thus over and under extraction is eliminated—resulting in a cleaner, high quality product.

HIGH PRODUCTIVITY

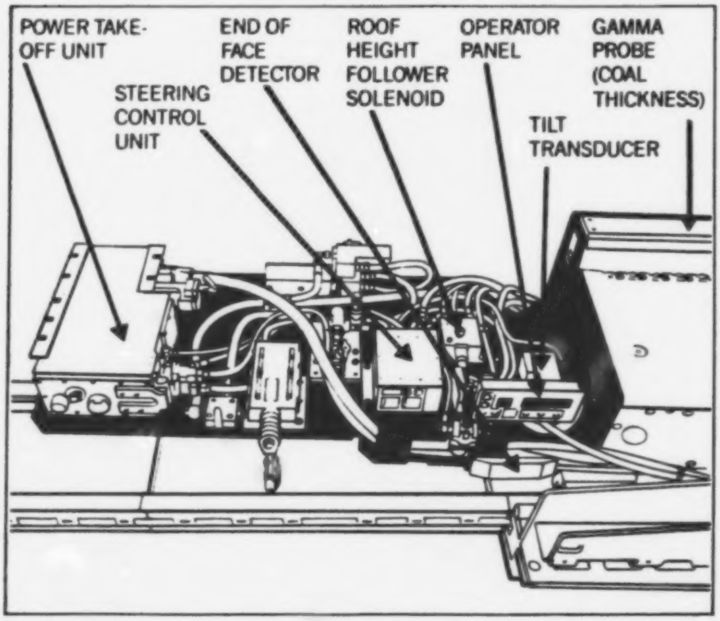
Superior face conditions brought about by improved floor and roof control coupled with the ability of the machine to cut at maximum rates under the guidance of the steering system ensure that high production rates can be achieved.

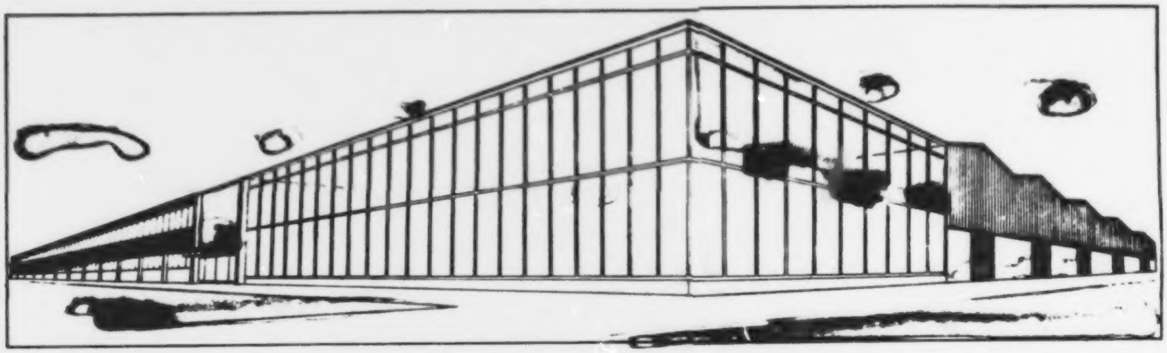
ELECTRONIC CONTROL PANEL

Manual control of the drum position is available via electronic push buttons located on the operator panel. The option of one or two panels is available.

GREATER SAFETY

Improved roof conditions ensure that the hazardous job of 'timbering up' of the roof is kept to a minimum.





MOVING TECHNOLOGY FORWARD

Since its beginnings more than a quarter of a century ago in Doncaster, Mining Supplies has established a formidable reputation for innovation and excellence in engineering.

With the successful development and manufacture of the spiral vane disc providing the foundation for growth in the early years, an impressive string of successes in solving other problems associated with the mining industry followed.

Today with engineering expertise and technological sophistication as keynotes of the operation, MS International plc is a group of eleven companies operating worldwide.

Mining Supplies (Longwall) Ltd is part of the group's mining division and has a total capacity in the design, manufacture, supply and repair of modern mining equipment.

Occupying a 23 acre site at Doncaster with some 396,000 square feet of office and factory space, the company supplies a comprehensive range of underground machinery. Face conveying systems, stage loaders and gearboxes—incorporating electronic control and microprocessor based health monitoring—where appropriate are just some of the sophisticated products designed and manufactured in Doncaster for applications throughout the world. A range of ancillary products, for example machine steering and in-line transducers, are also designed and manufactured.

And whilst the range is undoubtedly extensive, each product within it has one common objective—Moving Technology Forward.

MS MINING SUPPLIES (LONGWALL) LTD.

A subsidiary of MS International plc

Carr Hill, Balby, Doncaster
South Yorkshire DN4 8DH England
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Approved British Coal IS/Q.A.R.
BS.5750 Part 1

APPENDIX C

DIGITAL RADIO CONTROL SYSTEM FOR SHEARERS

ANDERSON STRATHCLYDE
EICKHOFF
GROUP CdF
M & C SWITCHGEAR

RADIO CONTROL FOR ANDERSON SHEARERS

To permit complete freedom of movement of the operator while controlling the machine it is fitted with a short range radio control system. This system consists of a transmitter, a receiver and aerial.

The transmitter is lightweight and is carried by the machine driver. It is powered either by an internal battery supply or by the normal cap lamp battery carried by the machine driver. In the former, a battery charging system is supplied for re-charging the batteries. This system should be located on the surface or in a designated safe area.

The transmitter can control up to 24 functions including a guard command, haulage control plus any other desired function. The radio control system is designed such that if the radio transmitter is switched off or the distance between transmitter and receiver becomes too great, the guard command signal is lost which causes the power to be disconnected from the machine.

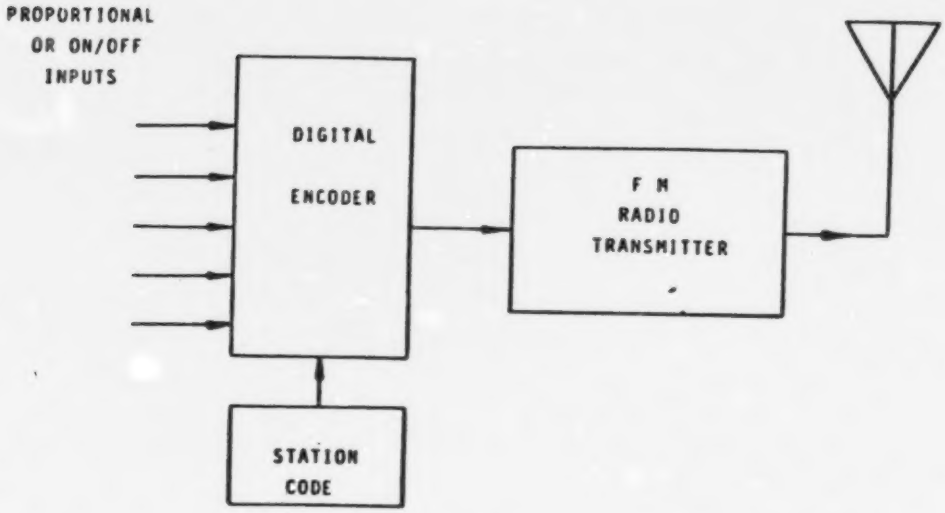
The receiver unit is mounted together with an interface unit on a removable chassis housed within the flameproof enclosure of the intermediate box. The receiver unit supplies signals to the haulage speed control unit which controls the speed and direction of the machine.

The receiver unit also supplies signals to power the solenoids which operate hydraulic valves which in turn operate the other desired functions.

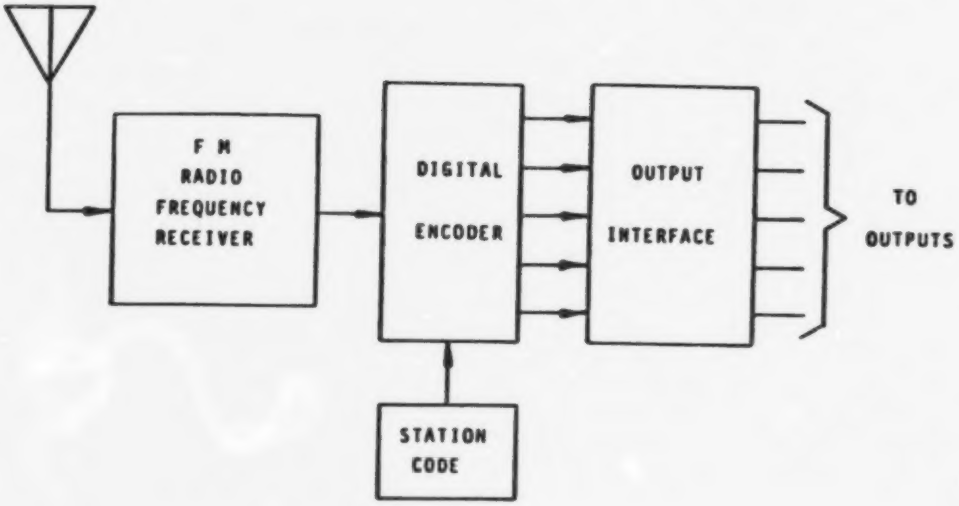
The receiver is powered from the machine's incoming power supply via fuses and transformers and failure of the receivers power supply will also cause the power to be disconnected from the machine.

The aerial is mounted at a suitable position on the machine and is connected to the aerial isolator in the intermediate box, a flameproof connector and a length of co-axial cable. The co-axial cable is protecte by an armoured hose where it runs on the outside of the machine.

DIGITAL RADIO CONTROL SYSTEM


PROPORTIONAL
OR ON/OFF
INPUTS
DIGITAL
ENCODER
F M
RADIO
TRANSMITTER
STATION
CODE

SEND SET


F M
RADIO
FREQUENCY
RECEIVER
DIGITAL
ENCODER
OUTPUT
INTERFACE
TO
OUTPUTS
STATION
CODE

RECEIVER

RADIO CONTROL OPERATING CONCEPT

The time t is measured from edge to edge and is typically 250 microseconds. This format allows the maximum data rate for a given transmission bandwidth with minimum sync requirements between the send and receive ends' clocks.

At the receiving end, the transmitted radio signal is received, demodulated and reconstructed into the t/2t format within the FM Receiver and then fed to the decoding logic. The logic recognises t as a zero bit and 2t as a one bit and inserts them serially into a shift register. As the data advances through the shift register, it reaches a position in the register where the code sent agrees with the code programmed into the decoding logic and the unique 4t marker has just been recognised.

At this instant, the switch/pot information bits are dumped into memory. This informtion stays in the memory until the next data frame updates it, or if no more valid data frames occur within a specified time, the memory is erased to all zero outputs.

The memorized potentiometer bits are reconverted by D/A converters into their respective voltage outputs, smoothed in time and buffered to drive valve coils. Typically, +/- 15 increments of output level correspond to 0 to +/- 100% of output. The memorized switch one/zero (i.e. ON/OFF) information operates pull-down transistors. These, in turn, operate relays whose contacts are the outputs to various ON/OFF machine functions.

To improve the integrity of the data link, a "one's count" scheme is included. The number of ones sent are counted in the encoding logic of the send end and are included in the last byte of the data frame. The receiver decoding logic counts the number of ones received in all but the last byte of the data frame and compares it with the number sent. This comparison check is an additional condition required to allow the memory to "read" the data received.

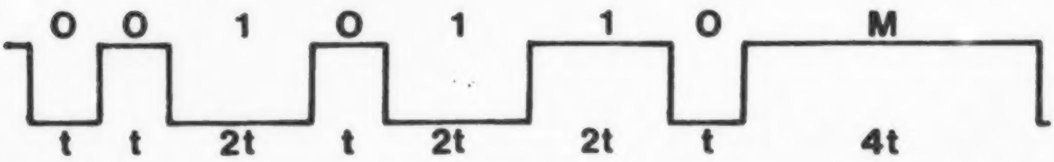
RADIO CONTROL OPERATING CONCEPT

In concept, the radio control data link is simple and straightforward. A block diagram of the basic link is shown in the attached figure. At the sending end, switch inputs and potentiometer voltage inputs are fed to a logic encoder. Voltages are converted by an A/D Converter to binary bits. Switches are inherently binary. This binary information and the particular station code used are scanned sequentially and fed out in a serial string to modulate the FM Transmitter and produce a radio wave with our sequence of binary information contained therein.

At the end of a sequence of scanning, a unique marker bit denotes the end of sequence or frame of data. This sequence of scanning is continuously repeated, ensuring a continual update of switch and potentiometer information.

For organisational purposes, the data frame is divided into a number of 8 bit bytes with bytes numbered and bits lettered A thru H. Thus, in a 7 byte data frame (i.e. 56 bits) bit 6G would be 47th in the sequence. The last bit (e.g. #56) is always the market bit.

The system uses the t/2t, non-return to zero, binary format with the marker being 4t, such that a serial binary sequence of 0, 0, 1, 0, 1, 1, 0, M out of the logic to the RF transmitter looks like this:



Anderson Strathclyde PLC

Leaflet 82-008

Anderson Moog radio system

The Anderson/Moog radio system is designed to provide a fail-safe method of remotely controlling machinery. It permits complete freedom of movement for the operator while controlling machine functions. The system is suitable for a wide variety of applications and is particularly suitable for the control of underground mining machinery in roadways and on the face. It consists of a transmitter, a receiver, an aerial isolator and an aerial; and the system is certified as intrinsically safe by UK and USA authorities.

TRANSMITTER

The lightweight transmitter is carried by the operator in a chest harness, and is powered by an internal nickel and cadmium battery supply. The battery provides a minimum of 10 hours operation per charge, and is re-charged by a special system located on the surface or in a designated safe area underground.

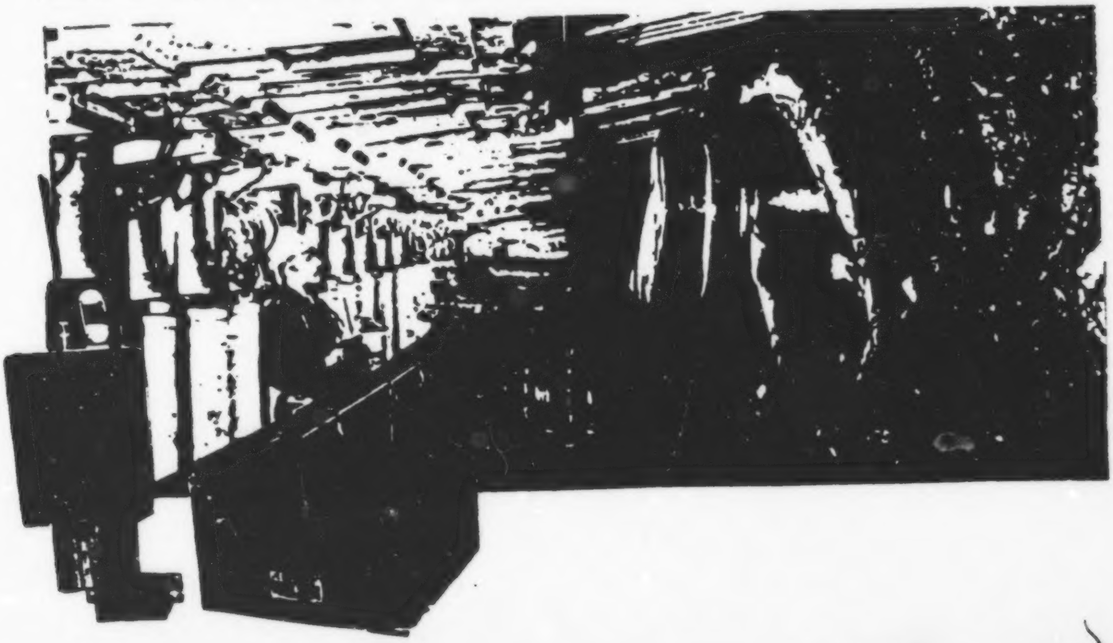
The transmitter controls up to 24 functions including a guard command together with haulage control and any other function as required. The radio system is designed so that if the transmitter is switched off, or if a pre-determined distance between the transmitter and receiver is exceeded, the guard command signal is lost and the power to the machine is cut off.

RECEIVER

The receiver unit and an interface unit are mounted on a removeable chassis housed in a flameproof enclosure within the machine. The receiver supplies signals to control the haulage speed and direction of the machine. This unit also provides signals to power the solenoids which operate hydraulic valves which, in turn, operate the other desired functions.

AERIAL AND AERIAL ISOLATOR

The aerial is mounted on the machine in a suitable position, and is connected to the aerial isolator, a flameproof connector and a length of co-axial cable. This cable is protected by an armoured flexible hose where it is routed on the machine's exterior. The aerial isolator acts as a barrier to any supply frequency fault appearing on the aerial.



Eickhoff-Funksteuerung für Bergbau-Maschinen

Eickhoff Radio Control for Mining Machinery

[illegible]

Die eigensichere Eickhoff-Funksteuerung ist für die Fernbedienung von Maschinen im Bergbau untertage entwickelt worden.

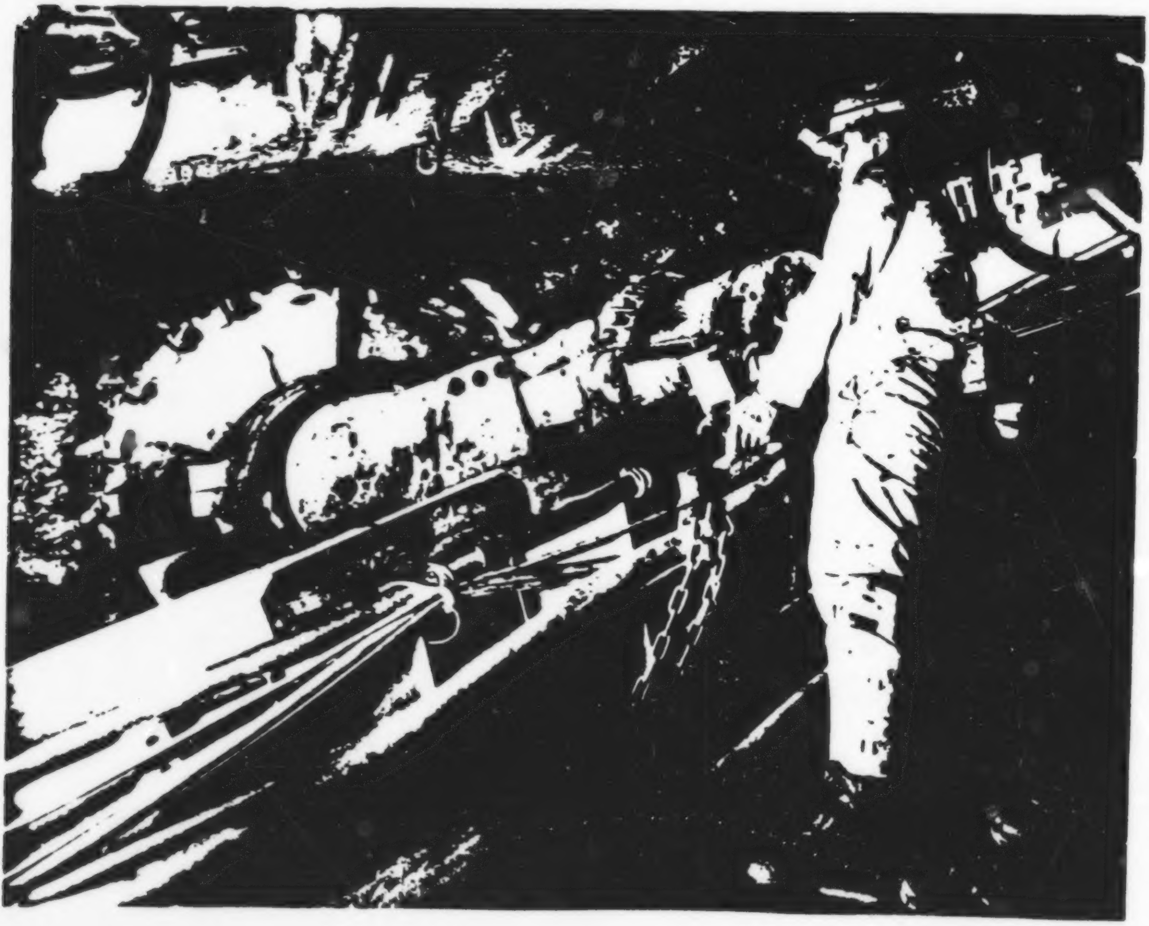
Die langjährigen Erfahrungen mit der Funksteuerung von Gewinnungsmaschinen haben zu einem Konzept geführt, das folgende wesentliche Merkmale hat:

- handlicher Sender mit geringem Gewicht und kleinen Abmessungen
- wahlweise Ein- oder Zwei-Senderbetrieb mit einem Empfänger
- einfache Bedienung durch Matrix-Tastatur mit eingeätzten Symbolen

The intrinsically safe Eickhoff radio control system serves for the remote control of machines used in underground mining.

The experience of many years gained in the radio control of power loaders has resulted in a concept which features the following:

- handy transmitter of low weight and small dimensions
- control by one or two transmitters and one receiver
- easy operation by means of a matrix keyboard with etched-in symbols



- geringer Stromverbrauch, Dauerbetrieb von ca. 16 h ohne Nachladung
- gemeinsamer, codierter Steckanschluß für Antenne und Ladeanschluß
- Empfängereinschub mit geringer Einbautiefe und Funktionsanzeige kompaktibel mit bisher eingesetzten Empfängereinschuben
- Empfangsmodul mit integrierter Antenne für PCM-Steuersysteme
- hohe Funktionssicherheit durch Pulse-Code-Modulation und Mehrfachuberprüfung der jeweils ausgelösten Funktion auf Übertragungsfehler
- hohe Betriebssicherheit durch modularen Aufbau und Verwendung hochintegrierter Schaltkreise
- hohe Frequenzstabilitat durch besonders ausgesuchte Quarze und Kompensationsbeschaltung

Komponenten der Funksteuerung:

1. Sender iFS-1

2. Empfänger-Einschub
für Ein-Sender-Betrieb IFE-2
für Zwei-Sender-Betrieb IFE-2

3. Empfänger-Modul IFE1/2
für Maschinen mit PCM-System

4. Ladegerät für 3 Sender

5. Wendelantenne 60 mm

- low current consumption, continuous operation over approx. 16 h without recharging
- common, encoded plug connection for the antenna and for charging
- receiver unit requiring little depth for installation, with function display, compatible with the receiver units used so far
- receiver module with integral antenna for PCM control systems
- high functional safety due to pulse code modulation and repeated checking of the function released for transmission errors
- high operational safety due to the modular design and large-scale integrated circuits
- high frequency stability due to especially selected quartzes and compensating circuitry.

Components of the Radio Control System:

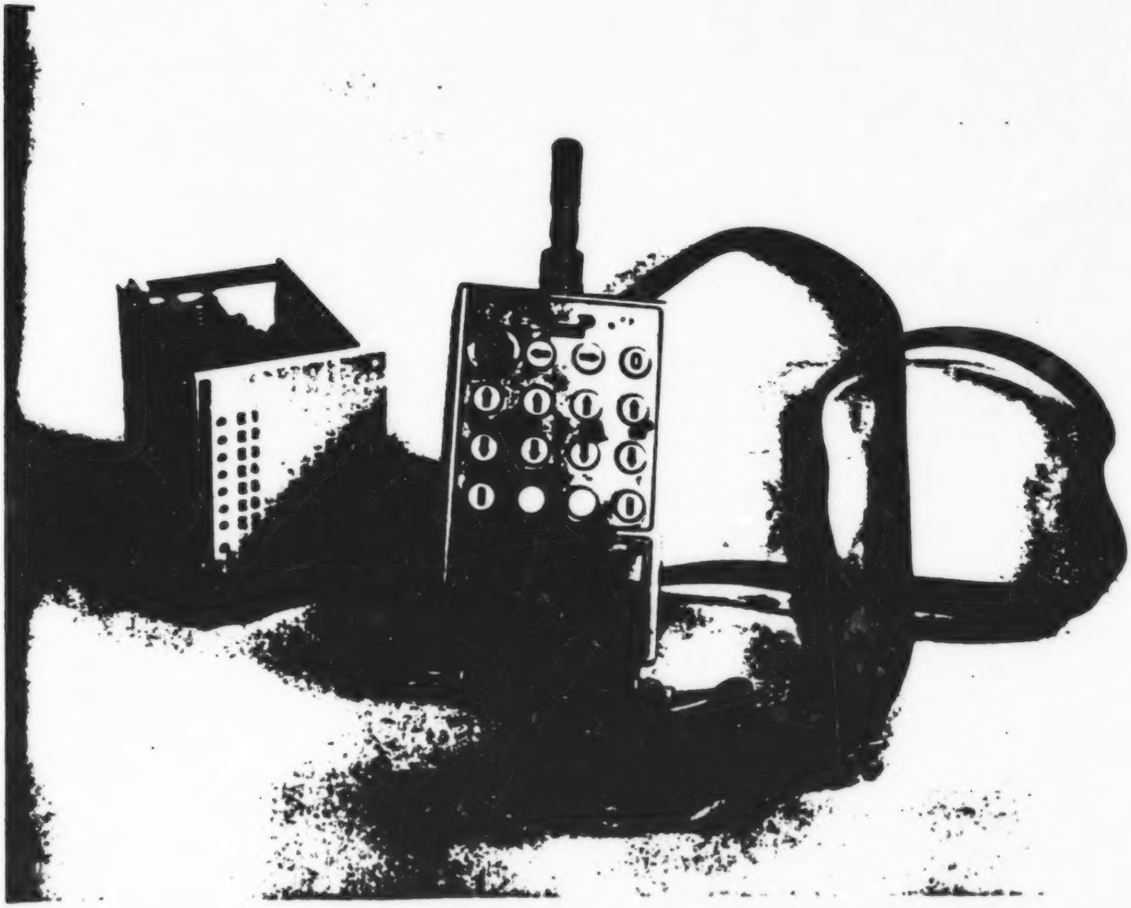
1. Transmitter iFS-1

2. Receiver unit
for single transmitter operation IFE-1
for two-transmitter operation IFE-2

3. Receiver module IFE 1/2
for machines with PCM system

4. Charging unit for 3 transmitters

5. Helical antenna 60 mm



Beschreibung

1. Sender iFS-1

Der Sender besteht aus Stromversorgung, Tastatur, Modulator und HF-Sendeteil, die in einem Edelstahlgehäuse eingebaut sind.
An der Stirnseite des Gehäuses befindet sich eine BNC-Steckbuchse zum Anschluß der Stabantenne. Hierüber erfolgt auch die Aufladung der eingebauten Akkus.
An der anderen Seite sind die Einschraub-Ösen zur Befestigung des Tragegurtes angebracht.
Die Befehlsgabe erfolgt über eine Matrix-Tastatur. Die Tasten sind mit entsprechenden Symbolen versehen (je nach Anwendungsfall).
Durch gleichzeitiges Drücken der beiden „Ein-Tasten" wird der Sender eingeschaltet, eine grüne Leuchtdiode zeigt dann den betriebsbereiten Zustand an.
Während des Betriebes wird dauernd der Ladezustand der Akkuzellen überwacht. Sinkt die Spannung unter den zulässigen Wert, schaltet der Sender automatisch ab. Ein Wiedereinschalten ist erst nach Aufladung der Akkus möglich.
Beim Betätigen der Funktionstasten werden digitale Datenwerte gebildet, in eine serielle PMC-codierte Information umgesetzt und auf den Modulationseingang des HF-Senders gegeben. Das über die Antenne abgestrahlte Signal im 70cm Band ist für die Ausbreitungsbedingungen im Streb besonders geeignet.

2. Empfänger-Einschübe iFE-1/iFE-2

Der Empfängereinschub besteht aus HF-Empfänger, Demudolator, Decoder und Ausgangsstufen, die auf vier Leiterplatten im Format 100 x 100 mm angeordnet sind. Die Leiterplatten sind zu einer Kompaktbaugruppe mit einer Breite von 5 SEP (76,2 mm) zusammengefaßt.
In der Frontplatte befinden sich Leuchtdioden, die die Betriebsbereitschaft, Störungen und die aktivierten Steuerkanäle anzeigen. Die Verbindung zum Baugruppenträger erfolgt über eine 48-pol. Steckerleiste und über eine Antennenbuchse.
Nach der Aufbereitung und Umwandlung der Signale im HF-Empfänger und Demudolator wird das jeweilige digitale Datenwort auf Übertragungsfehler wie Telegrammlänge, Baudrate, Parität und Synchronisation geprüft. Bei Auftreten eines beliebigen Fehlers wird die Signalausgabe für die gestörte Funktion gesperrt. Gleichzeitig erfolgt die Fehleranzeige über LED in der Frontplatte.
Eine Überprüfung der decodierten Signale auf Plausibilität stellt sicher, daß widersprüchliche Befehle nicht ausgeführt werden.
Während der Emfänger 1FE-1 nur mit einem Sender betrieben werden kann, ist bei dem Empfänger 1FE-2 der wahlweise Betrieb mit einem oder mit zwei Sendern vorgesehen. Die Erkennung der Betriebsart erfolgt selbsttätig beim Einschalten der Sender. Das Fehlen eines Trägers führt zur Abschaltung der Maschine. Da ein Wechsel der Betriebsart bei jedem Einschalten erfolgen kann, ist bei Ausfall eines Senders die volle Betriebsbereitschaft gewährleistet.

3. Empfänger-Modul iFE 1/2

Beim Empfänger-Modul sind der HF-Empfänger und die Empfangsantenne zu einer kompakten Einheit zusammengefaßt, die außen an der zu steuernden Maschine angebracht wird. Das stabile Stahlgehäuse hat an einer Längsseite die BNC-Steckbuchse zum

Description:

1. Transmitter iFS-1

The transmitter consists of the power supply unit, the keyboard, the modulator and the HF transmitter section housed in a special steel casing. A BNC socket provided on the front side of the casing serves for the connection of the bar antenna and also for charging the built-in accumulators.
The other side is provided with screw-in lugs for the attachment of the carrying strap.
A matrix keyboard serves for giving the commands. The keys are marked with symbols as required for a certain application.
The two 'on' push-buttons must be simultaneously pressed for switching the transmitter on, and a green LED will then indicate the ready state of the transmitter. During operation the charge of the accumulator cells is continuously monitored. If the voltage drops below the admissible value, the transmitter is automatically switched off and the accumulators must be charged before the transmitter can be switched on again.
When the functional keys are pressed, digital data items are formed, they are converted into a serial PCM encoded information and fed to the modulation entry of the HF transmitter. The signal radiated by the antenna in the 70 cm band is particularly suitable for the propagation conditions on the face.

2. Receiver Units iFE-1/1FE-2

The receiver unit consists of the HF receiver, demodulator, decoder, and output steps which are provided on four printed circuit boards of the size 100 x 100 mm which are combined to form a compact sub-assembly having a width of 5 SEP (76,2 mm).
The front panel contains LED's which indicate the ready state, troubles, and the activated control channels. The connection with the sub-rack is ensured by a 48-pole plug strip and the antenna bush.
When the signals have been processed and converted in the HF receiver and the demodulator the respective digital data item is checked for transmission errors such as telegram length, Baud rate, parity, and synchronization. If any errors occur the signal output for the disturbed function is locked. At the same time the error is displayed by the LED's in the front panel.
The decoded signals are checked for reasonableness, so that contradictory commands are not executed.
While the receiver iFE-1 is suitable for operation with one transmitter, the transmitter iFE-2 is designed for operation either with one transmitter or with two transmitters. The mode of operation is automatically recognized when the transmitters are switched on. If one carrier is missing, the machine is switched off.
As the mode of operation might be changed every time the system is switched on, the ready state is fully maintained in the case of a failure of one transmitter.

3. Receiver Module iFE 1/2

The HF receiver and the receiver antenna of the receiver module are combined to form a compact unit which is fitted outside to the machine to be controlled. The robust steel casing is provided on one side wall with the BNC socket for the connection of the bar

Anschluß der Stabantenne und an einer Stirnseite eine Flanschdose für die Steuerleistung. Da hier das aufbereitete NF-Signal abgenommen wird, sind keine abgeschirmten Leitungen erforderlich.
Der Einsatz des Empfänger-Moduls setzt voraus, daß die Maschine mit einem PCM-System ausgerüstet ist, wie dies z.B. bei Walzenladern mit Mikroprozessoren der Fall ist.

4. Ladegerät

Mit dem Ladegerät können gleichzeitig drei Eickhoff-Funksteuersender geladen werden. Alle drei Ladeplätze verfügen über eine Schnell-, Normal- und Erhaltungsladestufe, die sich sowohl manuell als auch automatisch (zeitgesteuert) betreiben lassen. Der Betriebszustand und die jeweilige Restladezeit werden über einen Umschalter auf eine gemeinsame Anzeige gebracht. Fällt die Spannung aus, wird die Restladezeit gespeichert und die Ladung bei Netzspannungswiederkehr fortgesetzt.
Zum Laden wird die Senderantenne abgenommen und der Sender über den Antennenstecker mit einem freien Ladekanal verbunden. Die Antenne kann für die Ladezeit auf eine freie Antennenbuchse des Ladegerätes gesteckt werden. Durch gleichzeitiges Betätigen des zugehörigen Kanaltasters und dem entsprechenden Ladeartentasters wird der Ladevorgang gestartet, dabei werden Ladeort, Ladezeit und Ladestrom angezeigt. Nach Ablauf der Ladezeit schaltet sich das Gerät auf Erhaltungsladung um.

antenna and on one front side with a flange-type socket for the control cable. As the processed LF signal is taken off at this point, no screened cables are needed.
The receiver module can only be installed if the machine is equipped with a PCM system as it is the case e.g. with shearer loaders having microprocessors.

4. Charging Unit

The charging unit allows for charging three Eickhoff radio remote control transmitters simultaneously. The three charging stations have a quick, a normal and a preservation charging stage which can be operated both manually and automatically (time controlled). The operating condition and the respective remaining loading time are indicated on a common display by means of a change-over switch. In the case of a voltage failure, the remaining loading time is memorized and charging continues when the mains voltage returns.
The transmitter antenna is removed for loading, and the transmitter is connected with a free charging channel by means of the antenna plug.
During charging the antenna can be plugged on to a free antenna bush of the charging unit. The corresponding channel button and the charging mode button are simultaneously pressed to start charging, the charging place, the charging time, and the charging current are indicated. After the expiration of the charging time the unit changes over to preservation charging.

Technische Daten:

Technical Data:

Sender IFS-1 · Transmitter IFS-1

Batteriespannung/-Kapazität · Battery voltage/capacity	9,6 V/452 mAh
Stromaufnahme · Current input	15 mA
Gewicht · Weight	860 g
Trägerfrequenzen · Carrier frequencies	433,42 433,92 434,42 MHz
Trägerkanalraster · Carrier channel spacing	500 kHz
HF-Ausgangsleistung am Antennenfuß · HF output at antenna base	10 mW
Übertragungsart · Transmission type	FM/PCM
Frequenzhub · Frequency deviation	± 50 kHz
Anzahl der Fernsteuerkanäle · Number of remote control channels	14
Übertragungsrate · Transmission rate	10 k Baud
Dauerbetriebszeit · Continuous operating time	approax 16 h · ca. 16 Std.

Bescheinigt durch die BVS nach EN 50020 E EX ial

Certified by BVS according to EN 50020 E EX ial

Empfänger IFE-1 · Receiver IFE-1

Ein-Sender-Betrieb · Operation with One Transmitter

Versorgungsspannung · Supply voltage	12 V ± 1 V
Stromaufnahme · Current input	70 mA
Trägerfrequenzen · Carrier frequencies	433,42 433,92 434,42 MHz
Trägerkanalraster · Carrier channel spacing	500 kHz
Treiberausgangsstrom · Driver output current	10 mA/Kanal · channel

Bescheinigt durch die BVS nach VDE 0170/2.61

Certified by BVS according to VDE 0170/2.61

Empfänger IFE-2 · Receiver IFE-2

Zwei-Sender-Betrieb · Operation with Two Transmitters

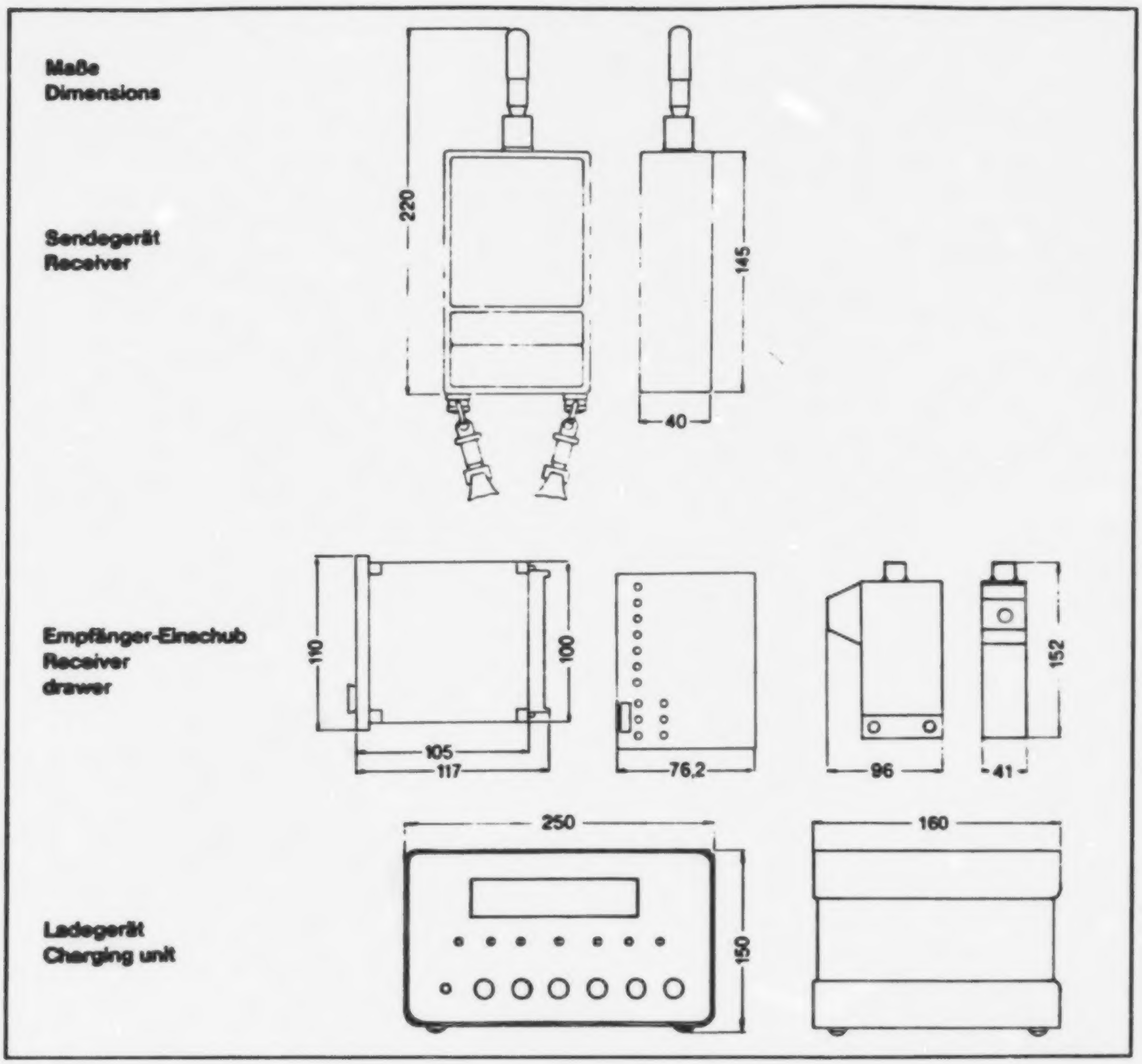
Versorgungsspannung · Supply voltage	12 V ± 1 V
Stromaufnahme · Current input	100 mA
Trägerfrequenzen · Carrier frequencies	433,42 und 434,43 MHz
Treiberausgangsstrom · Driver output current	10 mA/Kanal · channel

Bescheinigt durch die BVS nach VDE 0170/2.61

Certified by BVS according to VDE 0170/2.61

Ersatzteile/Zubehör · Spare Parts / Accessories

Wendelantenne · Helical antenna	
Trageriemen · Carrying strap	
Wirbellager · Whirl bearing	
Ladegerät · Charging unit	220 V, 50-60 Hz
Ladegerät · Charging unit	110 V 50-60 Hz
Anschlußleitung · Connection cable	


Maße
Dimensions
Sendegerät
Receiver
220
145
40
Empfänger-Einschub
Receiver
drawer
110
100
105
117
76,2
96
41
152
Ladegerät
Charging unit
250
160
150

GM / 2000 / DE / 6 / 86

Eickhoff

Gebr. Eickhoff
Maschinenfabrik und Eisengießerei mbH
Postfach 10 06 29, D-4630 Bochum 1
Telefon (02 34) 77 71-1, Telex 17 234 318 eick
Telefax (02 34) 77 71-4 77

TELSAFE® DV radio remote control system

The TELSAFE D.V radio remote control system is designed for direct view remote control of various operations performed by such machines as digging, mineral getting and drilling machines used in mines or public works, and operating in areas which can be dangerous for their operators

The number and the nature of control orders to be transmitted usually depend on the type of machines ; the TELSAFE D.V. system which uses a modular concept can be adapted accordingly.

Principle

Control signals which impose amplitude modulation upon a carrier wave are transmitted in a coded form by a transmitter to a receiver on the machine

A transmitter-receiver set constitutes a transmission channel. TELSAFE D.V. can comprise two transmission channels, in the case, for example, of machines operated by two men (such as double drum shearers). Each of the control signals transmitted consists of 13 information bits that are arranged and combined in a specific manner according to the type of orders transmitted : all-or-nothing type orders, orders for proportional control action. The system can be used for remote control from a distance up to 20 m in underground, confined surroundings

Description

Each of the transmission channels consists of :

- **a transmitter** carried by the machine operator and fitted with a 16-key panel, with speed control and emergency stop button

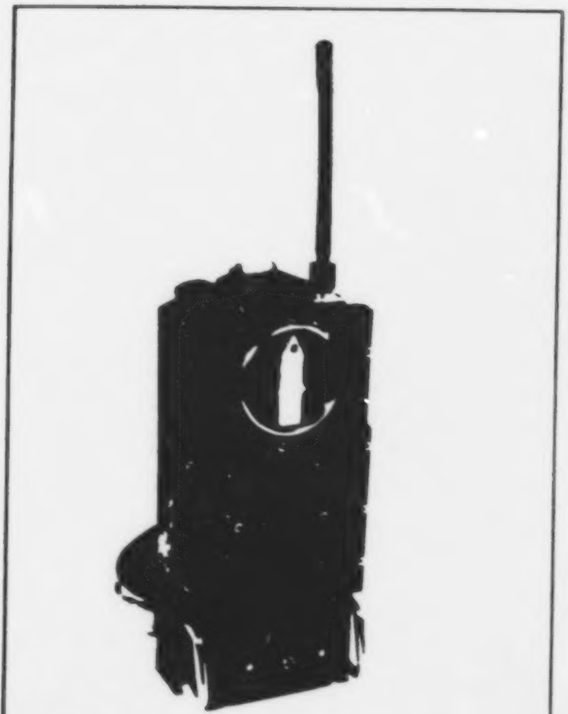
Dimensions :	250 × 130 × 50 mm (10x5x2 in.)
Weight :	3 kg (6 lb)
Carrier frequency range :	150 - 174 MHz
Output power :	100 mW
Battery	8 hours in normal operation
Antenna	15 cm (6 in.) in length

Intrinsically safe unit

- **a receiver unit**

It comprises the receiver proper, a decoder and a logic circuit for handling the binary signals and convert them into control orders. The receiver unit which has been the subject of extensive mechanical testing in a vibration machine is contained in a housing mounted on the machine, where it can operate at temperatures up to 100° C (212° F). It can also be housed in a flameproof casing for use in gassy mines.

The housing containing the receiver unit(s) can also be provided with electronic measuring apparatus connected to temperature and pressure sensors placed at different places on the machine. The measured values and the remote control orders can also be LED displayed on a control panel.



Advantages

- modular concept adaptable to different types of machines,
- protected against electromagnetic interference,
- intrisically safe, lightweight, easily handled transmitter,
- flameproof receiver,
- can be conveniently repaired underground thanks to easily accessible replaceable parts,
- vibration and shockproof,
- the receiver on the machine still operates at an internal temperature of 100° C (212° F),
- can be operated by two machines operators according to a given priority to insure absolute safety,
- a proportional order (speed) and one of 16 all-or-nothing type orders are transmitted simultaneously,
- fail-safe system designed so that radiotransmission failure causes the machine to stop automatically,
- equipment tested in particularly difficult workings.

Development and references

Units made by CERCHAR*, the research establishment of CdF, are operating on longwall shearers and dumpers (LHD) in French coal mines (Houillères du Bassin de Lorraine, Houillères d'Aquitaine).

* Centre d'Etudes et Recherches de Charbonnages de France

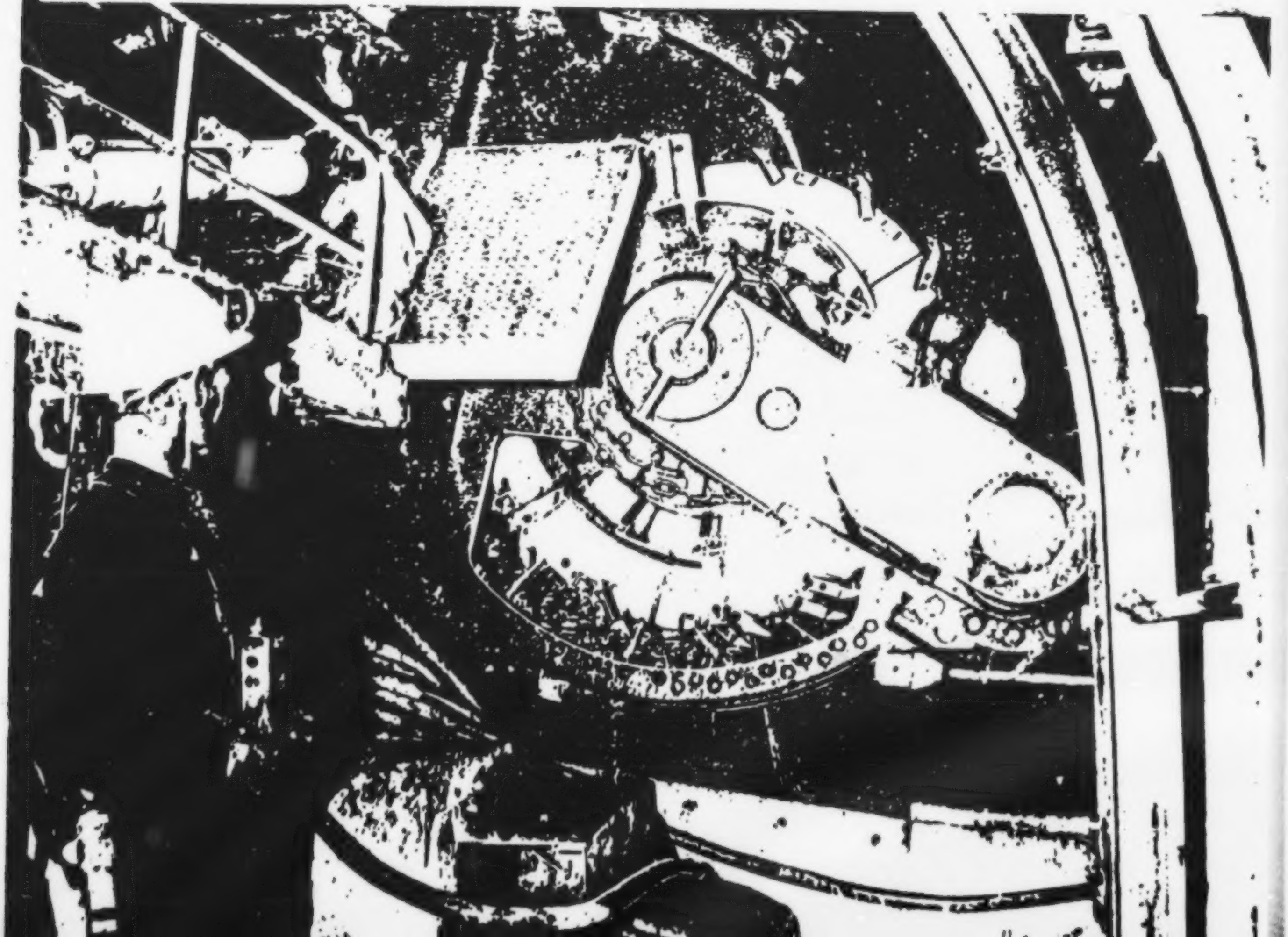
Your contact

GROUPE CdF

[illegible]
Clyde

M&C SWITCHGEAR

RADIO CONTROL SYSTEM CSP2



RADIO CONTROL SYSTEM CS12

Introduction

The CS12 radio system has been designed to provide a fail safe method of controlling remote equipment It is suitable for a wide variety of applications and, in particular, for the control of underground mining machinery Control is achieved by the modulation of a carrier frequency by a sequential code signal utilising 12 separate tone frequencies This allows a total of 17 functions to be performed A portable transmitter, complete with aerial and rechargeable battery, is carried by the operator, whilst the receiver is mounted within the controlled machine

For underground use, the system operates on VHF, and is designed to restrict the operational range to about 20 metres although this may be affected by the strata conditions and the degree of mechanisation If, therefore, the operator is separated from the machine by more than this distance, the equipment will cease to function and the machine will be de-energised For surface applications UHF would normally be utilized

The method of control is described below with reference to underground mining applications, followed by a more general description of system operation.

Control

A unique twelve tone, repetitive, sequential code signalling system is used in such a manner as to provide complete operational safety in the event of interference, equipment malfunction or component failure The transmitter code is generated by a single monolithic circuit element which is preprogrammed to standard tone frequencies A single resistor-capacitor network controls a master oscillator from which all tones are derived This results in an extremely simple setting up procedure and ensures excellent frequency stability High system reliability is, therefore, achieved without the need for complex equipment

The transmitter is equipped with a three position control switch In the first position the device is switched *off* and the machine is de-energised In the second position, designated *NORMAL*, all necessary functions are provided for the control of the machine whilst it is traversing the coal face The first of these functions is a guard command to maintain supply to the machine once the start sequence has been completed The other functions would include the haulage direction and speed commands, and control commands for the booms and the underframe In the third position, designated *AUXILIARY*, a number of other functions can be performed whilst the machine is stationary These can include cowl adjustments and initiation or disconnection of water supply

Application

Although the description above refers to mining applications, the CS 12 system can be utilized for the remote control of any machine or process

The following is a summary of the number of control functions available and the mode of operation

A Normal Control

In this mode, a total of three commands can be sent at any one time

1 Guard command This is a continuous command available whilst the transmitter is energised
2 Two normally *ON* commands These signals are transmitted for as long as the control switch is in either of its two active positions They are mutually exclusive, that is, only one command can be sent at any one time (These signals are used for control of the haulage when applied to shearers.)
3 Eight *push to operate* commands These signals are transmitted only when the appropriate button is depressed They are mutually exclusive, that is, only one command can be sent at any one time

B Auxiliary Control

In this mode, two commands can be sent at any one time

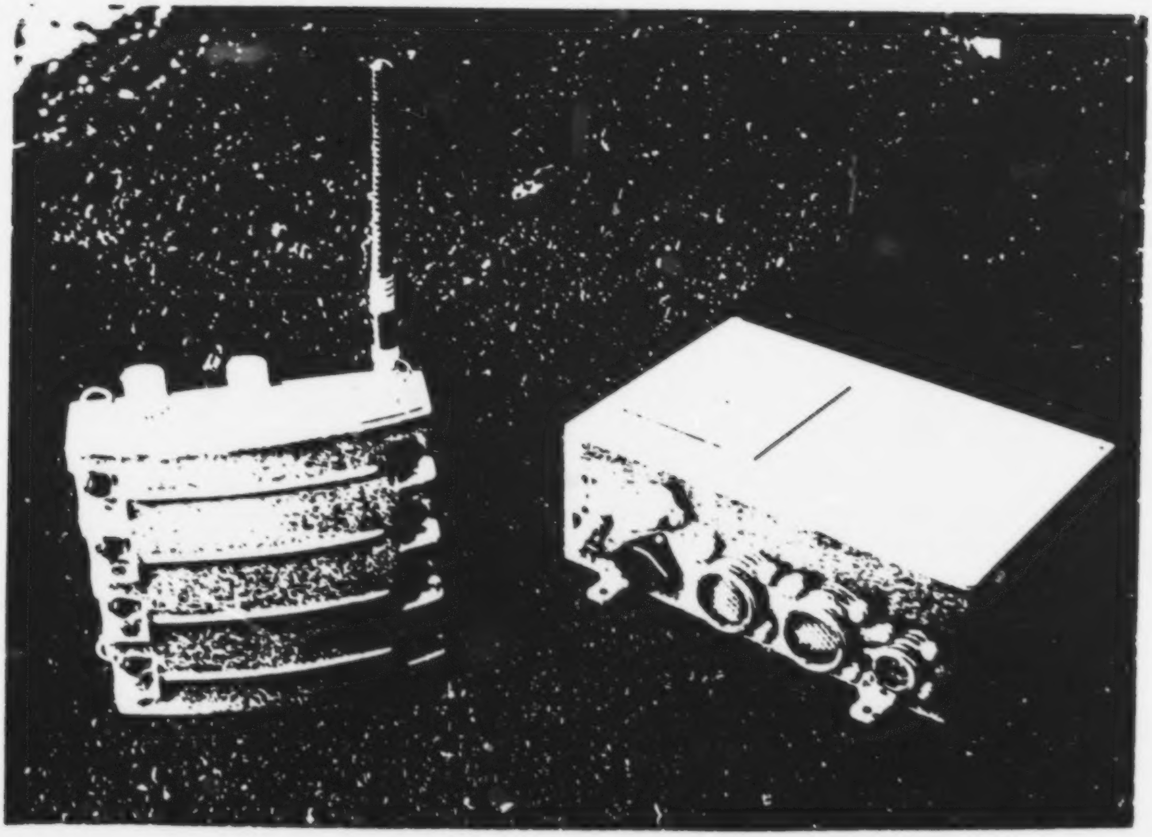
1 Guard command This is a continuous command available whilst the transmitter is energised
2 Six *push to operate* commands These signals are transmitted only when the appropriate button is depressed They are mutually exclusive, that is, only one command can be sent at any one time

As the guard command is common to both normal and auxiliary operation, the total number of separate commands available is 17

General

The plastic transmitter case provides a robust, lightweight enclosure which is designed to withstand the severe environmental conditions experienced in underground operations The removable, rechargeable battery provides a minimum of 12 hours operation under worst case conditions All printed circuit boards within the transmitter and receiver are fully potted to ensure reliable operation under conditions of severe shock and vibration and the system is designed to comply with the requirements for intrinsic safety for group I applications

M&C SWITCHGEAR



APPENDIX D

APPARATUS FOR INFRARED CONTROL OF MINING MACHINES

LICENSINTORG

MOSCOW USSR

APPARATUS FOR INFRARED CONTROL OF MINING MACHINES

In the USSR there is developed and offered through purchase of a license apparatus for wireless remote control of mining machines, such as stoping and entry-driving machines, by using an infrared communication channel.

The advantages of use of infrared radiation over the other types of telecontrol consist in that, contrary to the wire control, the present method does not require use of cable communication lines which can be easily damaged, and eliminates the action of electromagnetic interferences which constitutes an essential disadvantage of the apparatus operating at radio frequencies.

The offered apparatus consists of the two following parts: a portable panel equipped with a repleceable supply unit (a battery), from which the operator controls operation of the mining machine, and photodetecting devices and a control unit mounted on the mining machine. The photodetecting devices convert the infrared radiation received into electric signals which, after being processed, are supplied to the relay of the control unit. Within the limits of visibility of the object being controlled (up to 15–20 m) there is provided a stable transmission of commands, the reliability of control not depending on the mining, geological and technical conditions. The method of coding allows to transmit control commands simultaneously, in any sequence and in any combination. Therefore, the operator may stand in fresh air at a safe distance from the operating machine, which considerably improves the safety and other conditions of his work.

The offered apparatus is assembled from standard, easy-to-find components. It is much simpler and more technological in manufacture than the corresponding apparatus used for control by radio, for instance, it does not require such a relatively complicated operation as tuning-up radio-frequency circuits.

Use of the offered apparatus in breakage faces has proven its high reliability and economic efficiency (as compared to the manual control of mining machines, the labour productivity in increased by 18–20%).

Technical Data

Range of operation, m	up to 20
Number of commands	22
Power of radiation, Wt	at least 0.18
Length of radiation wave, mcm	0.95
Duration of continuous operation of the control panel without recharging the battery, hr	at least 7
Supply voltage, V:	12
control panel	12
receiver	24
Weight of the control panel, kg	1.5

A know-how is offered through purchase of a license.

For information on licensing terms, contact V/O Licensintorg,

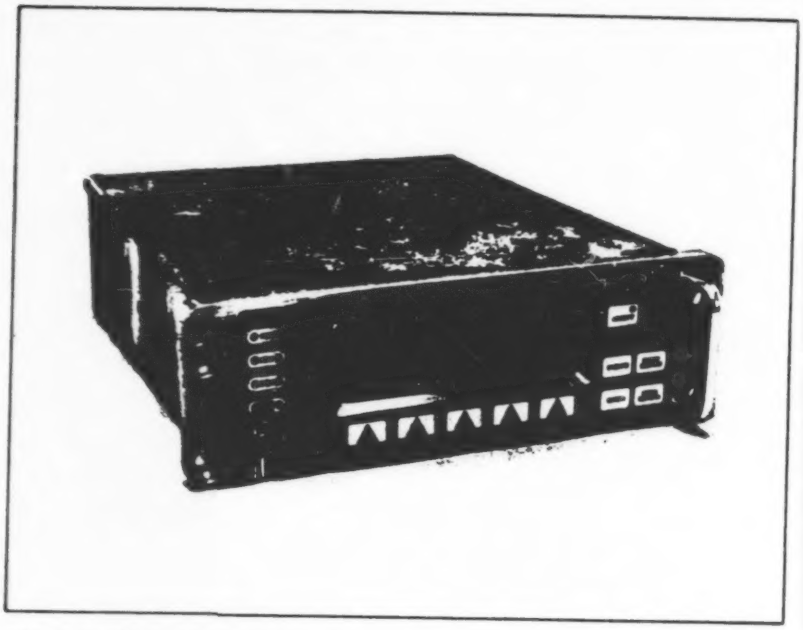
11, MINSKAYA UL., 121108 MOSCOW, USSR.
TELEPHONES: 145 27 00 AND 145 31 32 TELEX: 411415

APPENDIX E

MULTI-PURPOSE AUTOMATIC CONTROL EQUIPMENT (MACE)

British COAL

Headquarters Technical Department



MACE module for a shearer

Multipurpose automatic control equipment (MACE)

INTRODUCTION

Multipurpose Automatic Control Equipment (MACE) is a general purpose, intrinsically safe, machine-mounted multi-processor facility which has been specifically designed to meet the automation requirements of British Coal for all types of underground mobile machinery. MACE has been developed by Headquarters Technical Department (HQTD) as a standard monitoring and control system which conforms to British Coal's communication standards, accommodates various hardware configurations and provides automation for different applications quickly and simply. The MACE design aims to guarantee long life in that it overcomes the risks of computing hardware becoming obsolescent or superseded. It caters for future developments by conforming to communications standards and easily accommodating further hardware expansion. This standard approach avoids duplication of effort, eliminates the need for application-specific monitoring and control designs, and minimises development costs, training and the holding of spares. MACE will be used at HQTD for automation development and the strategy is now available to suppliers of the mining industry. It offers suppliers an excellent opportunity to maximise the exploitation of their products within British Coal by basing their future system designs on the MACE strategy.

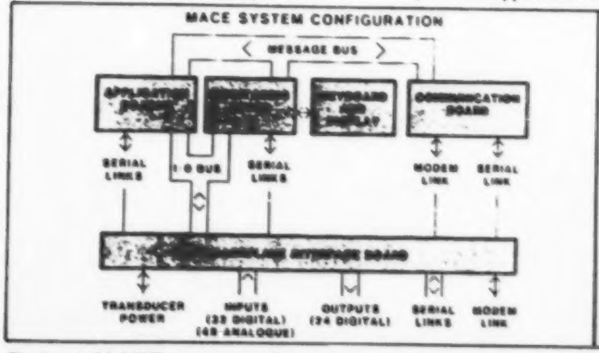
MACE HARDWARE

The MACE philosophy is to design automation systems having high system integrity so that reliable applications are exploited throughout the mining industry. This high integrity is achieved through each individual intelligent unit having the capability to operate independently so that the risk of total system failure is minimised. These intelligent units communicate with each other at a system level to provide additional integrity and diagnostic capability. This approach restricts bus traffic to the less time-critical functions such as data logging and display.

The strategy comprises a set of double Eurocard size boards based on 16 bit Intel 8086 CMOS technology which communicate through the HQTD designed backplane known as message bus so that they are compatible with local outstations which communicate with the surface at 64 kbits/second and are known in the British Coal standard systems as waystations. These boards are configured to reside within a module, the dimensions of which are dependant on the particular application. A typical hardware configuration is shown in Figure 2 where the standard system functions are seen to be performed by a monitoring board and a communications board which interface by message bus to one or more application boards. A design objective has been to achieve structural independence at board level so that each board essentially acts as a single board computer in that it houses its own microprocessor and support devices.

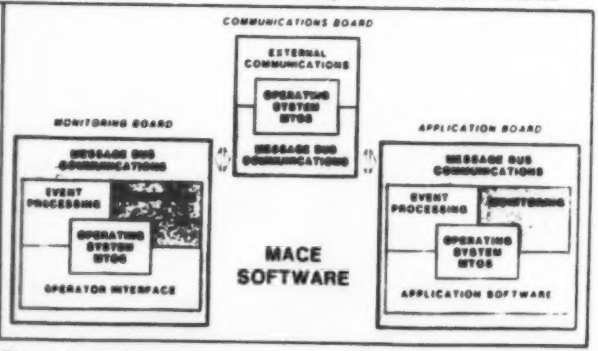
The configurable monitoring board with its interface to the keyboard and display and standard input/output (I/O) forms the heart of MACE. The photograph shows a typical MACE module for a shearer application where the LCD display operates in either alphanumeric or graphics mode, a number of LEDs give system status and health data and both *fixed* and *soft* key functions are available to the operator. A back-plane board provides current limiting and monitoring circuitry for the transducer power supplies as well as filtering and transient protection for module inputs. The monitoring board also has a serial link for connection to a local terminal if the application requires more comprehensive keyboard and display facilities.

The communications board comprises two separate microprocessors to handle both the



MACE SYSTEM CONFIGURATION
MESSAGE BUS
COMMUNICATION BOARD
DISPLAY
SERIAL LINKS
I O BUS
SERIAL LINKS
MODEM LINK
SERIAL LINK
INTERFACE BOARD
TRANSDUCER POWER
INPUTS (32 DIGITAL) (48 ANALOGUE)
OUTPUTS (24 DIGITAL)
SERIAL LINKS
MODEM LINK

Figure 1 MACE system configuration



COMMUNICATIONS BOARD
EXTERNAL COMMUNICATIONS
OPERATING SYSTEM MTOS
MESSAGE BUS COMMUNICATIONS
MONITORING BOARD
MESSAGE BUS COMMUNICATIONS
EVENT PROCESSING
OPERATING SYSTEM MTOS
OPERATOR INTERFACE
MACE SOFTWARE
APPLICATION BOARD
MESSAGE BUS COMMUNICATIONS
EVENT PROCESSING
MONITORING
OPERATING SYSTEM MTOS
APPLICATION SOFTWARE

Figure 2 MACE software

internal and external communications associated with the MACE module A Motorola 6805 processor performs the message bus controller function for the transfer of all internal data and has access to a small amount of dual port memory located on each board An Intel 8086 processor establishes and maintains links with other intelligent devices through underground serial links which may operate at configurable data rates up to 64k bits/second The communications board also interfaces to the MACE Modem for trailing cable transmission, the modem acting as a non-intelligent electronic unit working in asychronous half-duplex mode. The modem which is being proposed as an industry standard for machine-gate transmission has selectable baud rates, a *line quiet* signal and a test mode. MACE data is routed through the modem to a waystation where a protocol conversion to HDLC is performed prior to surface transmission at the standard 64 kbits/s

Application boards are single board computers constructed to fulfil a particular requirement within the context of the application environment A set of standard boards which interface to standard I/O channels has been developed These boards may be complemented by other designs to satisfy additional applications as required, it should be noted that application boards do not necessarily have to be based on Intel products The MACE hardware design makes use of existing power supplies, transducers and cabling wherever possible In shearer vertical guidance applications, MACE is supplied from a MIDAS power supply unit and uses the MIDAS Machine Movement and Direction Detector (MMADD)

MACE SOFTWARE

A fundamental design concept of MACE is to fulfil a wide variety of monitoring and control applications without recourse to the redevelopment of basic monitoring software. A basic monitoring system has therefore been developed around the monitoring and communication boards which is independent of application This application independent software interfacing to standard I/O provides a comprehensive configurable monitoring facility which is easily interfaced with application boards and their application-specific software. The structural independence of MACE software is shown in Figure 2 where each board is seen to have a common operating system and message bus communications function Both the monitoring and application boards are seen to have common tasks fulfilling the monitoring and event processing functions The basic MACE monitoring system also includes operator interface software in the monitoring board and external communications software in the communication board All this software is standard and independent of application The application specific software purely forms part of the application board software.

MTOS has been selected as the real-time operating system because it is available on a number of hardware configurations, it has been validated on many systems spanning more than a decade and it is efficient The MTOS operating system is written in assembler but the remainder of the basic monitoring system has been written at HOTD in PASCAL because it is a structured, well supported and portable language. MTOS is a simple multi-tasking operating system which is resident on each board within an application module and comprises a kernel and the necessary run-time routines Each kernel is responsible for scheduling, running and monitoring the performance of the particular tasks on the board as well as supervising the integrity of the system at both board and module level The actual run-time routines present on each board are those required by the compiler and the system for the board to perform its particular function.

The basic MACE module will require configuring to reflect the particular environment in which it will operate. The configuration process involves the definition of channel descriptor blocks to describe each input channel. These blocks give data on input ranges, conversion factors, sampling rates, filtering requirements, etc The configuration may be done at any time prior to use of the module and may be performed interactively using a remote terminal such as Anderson Strathclyde's hand-held device or by downline-loading a predefined configuration from an external intelligent device such as HOTD's SUMMIT (Supervisory machine monitoring information terminal) Once installed the configuration may be changed at any time After configuration the basic monitoring task will be able to monitor predefined channels at a predefined rate, perform selected signal processing, validate transducer readings, issue alarms and disable persistently erroneous channels.

It is essential that MACE applications meet British Coal's Electrical Acceptance Scheme requirements and provide reliable automation So it is a key objective that the basic monitoring system is designed to have high integrity Software driven watchdogs exist on each board to monitor board status which is indicated on a module LED and also transmitted to other boards within the module At the task level, MTOS monitors the performance of each task and status reports are issued to both the monitoring and communications boards which will independently indicate the occurrence of an error or malfunction. Extensive checks are also carried out on sensitive data to ensure security.

APPLICATIONS

Although MACE has specifically been designed for the automation of mobile machinery in the harsh mine environment, it is equally suitable for the monitoring and control of surface applications Some examples of underground applications are given below which give some measure of the versatility of the system.

Shearer vertical guidance: SERDS and DERDS, all methods of mining Natural Radiation and Pick Force systems Its first use will be controlling a 2-pass DERDS machine in 1987/8.

Horizontal guidance: A MACE unit could give both face alignment and chock control

Coal heading machines: In-seam Miner vertical guidance and control of machine advance

Tunnelling machines: Control of profile, line of advance and load

Face end machines: Control of profile and load.

Transport systems: Bunker automation, cement bulk handling, dirt disposal

MACE has sufficent capacity to also provide, at the machine, full condition monitoring for all the above applications which will lead to integral on-line machine diagnostic packages in the future. The use of the MACE strategy is seen to offer numerous benefits, the prime ones for British Coal being systems which have an application independent nucleus, which ar designed for future expansion and which conform to British Coal's emerging standar Additional technical benefits which accrue the use of a standard system with standard communications are applications which can readily integrated thereby reducing cabling for data transmission Benefits to suppliers MACE include reduced development costs exploitation and the potential for increased market share

EXPLOITATION

The MACE strategy has been developed to encourage the exploitation of automation w British Coal by suppliers developing system which conform to standards laid down by B Coal Potential suppliers can take the basic MACE boards and system software and interface to it their own application requirements This may be achieved in a nu of ways, the main options being given below where it is assumed that the standard basic monitoring system resides on Intel 8086 monitoring and communications boards

1. The supplier can use the standard basic monitoring system and supply the application board(s) and application software himself This option provides s choice of processor for the application board(s) given that the application desig meets the monitoring system interface requirements It also allows freedom of choice of language for application softwa
2. The supplier can use the standard basic monitoring system with an application board MACE software kernel. In this ca the application board(s) must be Intel 80 but the application software is the responsibility of the supplier.
3. The supplier can provide an application specification which is acceptable to the MACE basic monitoring system so that HOTD can build a complete MACE application system. Initially, these system will be based on Intel hardware.

TYPICAL MACE TECHNICAL DATA (SHEARER GUIDANCE)

MACE Module

Single IS Power Supply — 10 V at 600 mA

Processor — Intel 80C86 operating at 5 MHz

Memory/Board — approx 900 kbytes

Inputs — 46 Configurable Analogue Channel
24 Configurable Digital Channels
8 Pulse Channels

Outputs — 24 Digital Channels
(Up to) 12 Analogue Channels

Others — 6 Local Serial I/O Channels
2 Modem Channels

Features — Real Time Calendar Clock
Monitored supplies to transducer
5 Soft keys/5 Fixed keys
Graphics Display: 256 × 64 pixel
Module Health LEDS

MACE Modem

- Asynchronous Half Duplex Operation

Available for both Type 7 and Type 7S cables

Selectable baud rates up to 64 kbits/s

Standard-Type Modem Interface

Incorporation of *Test Mode* to allow data to be reflected back to its source

For further information apply to
Manager Automation and Advanced Mining, British Coal, Headquarters Technical Department Ashby Road Stanhope Bretby, Burton-on Trent DE15 0QD

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March 19

APPENDIX F

PRINCE REMOTE MONITORING SYSTEM

Source: (CBDC)

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

APPENDIX F
PRINCE REMOTE MONITORING SYSTEM
(Source: CBDC)

1.0 INTRODUCTION

The Remote Monitoring System at Prince Mine, installed in 1986, constantly monitors performance conditions throughout the mine and selected surface equipment. At the present time, the areas to be monitored include the operating wall faces, the main fan and the surface plant. The system consists of suitable transducers installed at various locations to monitor conditions and a series of outstations designed to collect data from a group of transducers in any one area and transmit it. This information is sent to a computer based facility installed on the surface which in turn stores the information and displays it in a desired format on command. The collection, transmission, storage and display equipment is all supplied by Transmitton Ltd., of Ashby de la Zouch, U.K.

There are three types of outstations used in this system (as configured) - wall outstations, surface and main fan oustation. Each is connected to a single multipair cable running the extent of the system and back to the central station on the surface. Also included in the cable is a communications system. The wall outstations include facilities for monitoring methane on the bottom level intake, methane in the return air, air velocity on the bottom level intake and return and CO on the intake and return. The fan outstation includes readings of airway methane, airway air velocity, airway carbon monoxide, fan water gauge, bearing temperature and bearing vibration. The surface outstation monitors barometric pressure, ambient air temperature and mine electrical load.

The Central Station consists of storage and display facilities for the collected data, uninterruptable power supply and communications. A processor is included that collects and sorts data as well as initiates alarms at pre-programmed set-points and continuously displays selected data. It also has the facility to print out this information as well as generate shift reports, alarm summaries, etc. Displays and hard copy print outs of trend logs, graphic pictures and customized read outs can be obtained.

The advantages of having a remote monitoring system at Prince Mine are as follows:

.1 Early warning of dangerous conditions in the mine.
.2 Costly breakdowns could be avoided by early detection of abnormal conditions in the equipment.
.3 Some equipment could be controlled directly from the surface.

2.0 COMPUTER AND ANCILLARIES

2.1 CENTRAL STATION

The surface (Central Station) equipment consists of two identical computer units, each consisting of a primary computer and front end driver (FED).

The primary computer is the heart of a telemetry system for control and monitoring of surface and underground plant and for providing display and analysis of plant operation, faults and environmental conditions.

Remote outstations are used to locally control and monitor and communicate with a Front End Drive (FED). The FED takes the form of a single card included in the primary bookcase. Each FED may support two low speed (e.g. 600 baud) telemetry rings of up to 14 outstations per ring and is responsible for reporting changes in outstation status to the primary across a serial medium speed link (9600 baud). Information from the primary may be displayed on a single control VDU plus up to four remote terminals. A system printer provides hard copy of logs and configuring data.

The primary computer is fully configurable and provides the user with great flexibility of customizing displays and control functions. Configuring data is saved on a magnetic tape cartridge which also serves as a program loading device.

The computer hardware is built from the Transmitton MC series card range based on the Intel 8085 processor. The program runs in RAM which is backed up by battery in case of power failure.

The system software is built from a library of standard application packages, written in CORAL 66 and assembler and included according to the required system functions and available memory.

2.2 OUTSTATION DESCRIPTION

The outstation provides the interface between the central station and the external plant and transducers. The outstation provides:

- A serial link to the telemetry ring.
- 32 digital inputs.
- 14 analogue inputs.
- 8 relay (I.S.) outputs.
- Door display of outstation status (LCD display).

The configuration of the input/output functions, alarm set points and displays may be changed by installing a new EPROM in the oustation.

The outstations are powered by a CPS3 power supply complete with battery backup. The supply is regulated at 8.5 VDC.

APPENDIX G

LINGAN REMOTE MONITORING SYSTEM

Source: (CBDC)

REMOTE AND AUTOMATIC CONTROL SYSTEMS FOR LONGWALL MINING
A REVIEW REPORT ON POTENTIAL APPLICATIONS FOR THE SYDNEY COALFIELD

APPENDIX G
LINGAN REMOTE MONITORING SYSTEM
(Source: CBDC)

1.0 INTRODUCTION

The Remote Monitoring System at Lingan Mine, installed in 1984, constantly monitors the methane extraction process, performance conditions thoughout the mine and selected surface equipment. At the present time, the areas to be monitored include three operating wall faces, three operating pumping stations, the main fan and the surface methane extraction plant. The system consists of suitable transducers installed at various locations to monitor conditions and a series of outstations designed to collect data from a group of transducers in any one area and transmit it. This information is sent to a computer based facility installed on the surface which in turn stores the information and displays it in a desired format on command. The collection, transmission, storage and display equipment is all supplied by Conspec Controls Ltd., of Dowsview, Ontario.

There are four types of outstations used in this system: wall outstations, pumping station outstations, a surface fan outstation and a methane extraction plant outstation. Each is connected to a single main multipair cable running the extent of the system and back to the central station on the surface. Also included in the cable is a communications system. The wall outstations include facilities for monitoring methane on the bottom level intake, methane in the return air, air velocity on the bottom level intake, top level fresh air split and inbye and outbye cundy holes (where applicable). Facilities are also included for monitoring methane flow and quantity in the methane extraction system. The pumping station includes inlet water flow, sump water level, discharge water pressure, motor load, bearing temperature and vibration, motor status and pump control. The fan outstation includes readings of airway methane, airway air velocity, airway carbon monoxide, fan water gauge, barometric pressure, ambient air temperature, mine electrical load, bearing temperature and bearing vibration. The methane extraction plant outstation includes facilities for monitoring inlet and outlet flow, methane quantity and pressure as well as various plant performance parameters.

The Central Station consists of storage and display facilities for the collected data, uninterruptable power supply and communications which are located in a separate room dedicatd to that purpose. A processor is included that collects and sorts data as well as initiate alarms at pre-programmed set-points and continuously display any selected data. It also has the facility to print out this information as well as generate shift reports, alarm summaries, etc. A second processor is included to generate color graphics, manipulating the stored data into more useful forms.

Displays and hard copy print outs of trend logs, graphic pictures and customized readouts can be obtained.

The advantages of having a remote monitoring system at Lingan Mine are as follows:

1. Early warning of dangerous conditions in the mine.
2. Costly breakdowns could be avoided by early detection of abnormal conditions in the equipment.
3. Some equipment could be controlled directly from the surface.

2.0 CENTRAL STATION DESCRIPTION

The Senturion 200 has a high performance disk system which provides 256 thousand words of program memory. This allows storage of frequently used data and programs with a non-volatile memory. It is possible to save programs on the disk, reprogram back off the disk, and other functions. All information is displayed on a Televideo Model 925 display terminal which has a detachable keyboard and a split screen format. This allows the operator to enter or access data while at the same time, display valuable data. The video display is 12" diagonally, it displays real time data, echos operators commands, reports system activity and visually reports alarms. The printer used for this system is a 132 column Mannesman Tally 18° printer. It has programmable parameters (character spacing, lines per inch, etc.), bi-directional print, double width and boldface printing, underline and elongated printing along with serial and parallel interface ports.

The central unit has an uninterruptable power supply to provide continuous operation for 4 hours. It supplies a sine wave output at 115 VAC and 5 amps from a rechargeable battery supply.

The color graphics part of the system consists of 208000 words RAM 7000 words EPROM and a 10 Mega Byte Winchester Drive. An additional 1.25 million words can be stored on each floppy disk. There is a 19 inch screen also provided. It will display six colors plus black and white. Graphics can be generated from a set of standard symbols supplied.

These graphics can be printed on the IS 8001 Printacolor. The printer uses three process colors to produce four additional colors. It will print unindirectionally and bi-directionally with a resolution of 90 dots per inch horizontally and 85 dots per inch vertically.

The station also has another 19 inch display and keyboard which can be used with the Senturion System or the graphics system. There is room for a total of four 19 inch color terminals. There are accessors present which provide the communication link between all field devices and the control processor. The Senturion 200 has room for four accessor trunks, two are presently being used.

3.0 OUTSTATION DESCRIPTION

An outstation provides a remote monitoring and control facility for the Conspec Senturion 200 computer. The field hardware consists of accessors which provide a single point data transmitter/receiver processor which is intrinsically safe. They are powered from a 4 wire data trunk wired in parallel with the trunk. All data communication to and from the accessor is made via a 22 bit message, which is comprised of eight check bits and seven bits identifying the accessor. More than 50% of the transmitted data is checking information. The 200 system supports 512 accessors, 128/trunk. The accessor trunk consists of 4 wires, 2 for power and 2 for data.

The underground outstation is comprised of a remote I/S trunk driver, local alarm station, start/stop relay station and a trip relay station. The surface station located at the fan is comprised of a remote I/S trunk driver, local alarm station and a relay station. Each outstation provides remote monitoring of up to eight I/S analog 0.4 - 2.0V instruments and up to 10 supervised I/S contacts, local visual indication fo alarms associated with those inputs, relay contact outputs to drive non I/S control circuits reflecting the normal/alarm status of up to three monitored inputs, three pairs of start/stop relay contact outputs to drive non I/S control circuits which are controlled directly by means of the Senturion Keyboard through commandable accessors, local visual indication of accessor trunk communication status and a battery back up for 8 hours in the event of power outages or brownouts.

The remote I/S trunk drivers provide a source of intrinsicially safe DC power in a field location remote from the Senturion computer. It also provides an I/S data communication channel through which the Senturion can command accessors located in hazardous areas. A twisted-shielded pair of wires link the Senturion to the trunk driver via modems and a 4-wire accessor trunk cable links the trunk driver with the accessors. These units are equipped with a 24V 20AH gel cell battery which will energize the trunk driver, all accessors and instruments powered from the accessor trunk for approximately 10 hours. A DC power supply provides 4 amps. at 26 VDC to power the I/S power supply.

There is a modem which allows Senturion accessor data to be transmitted over long distances on a single pair of wires. Wired between this modem and the trunk driver is a modem interface card. This card delays data being transmitted to the modem while the modem carrier is turned on and detected by the central modem. It also generates the "Request to Send" signal for the modem. There is also a communication barrier made up of a fuse-resistor zener diode which limits the voltage on either of the lines in the twisted pair to 12 volts with respect to ground.

4.0 SOFTWARE PACKAGES

4.1 BASIC SOFTWARE

This package includes scanning and reporting of all Binary and Analogue points for the following:

- Video terminal and keyboard communication.
- Alarm printer communication.
- Data printer communication.
- Time and date routine.
- English language prompt routines.
- Assign an alarm.
- Add new accessor to any trunk.
- Delete accessors from scan.
- Keyboard access codes junior and senior.

4.2 IMMEDIATE STATUS

Checks the present status of any device or analogue in the system.

4.3 ALARM SUMMARY

Lists points in the system in alarm.

4.4 DESCRIPTOR LOG

Lists all points in the system or operator selections such as status codes, reporting mode, physical accessor type used and accessor addresses.

4.5 ACCESSOR SCAN LIST

Lists accessors that are installed and indicates which ones are being scanned.

4.6 CONTINUOUS STATUS DISPLAY

Lets operator call up any six points to be continuously displayed and updated on the CRT.

4.7 START/STOP PROGRAM

Allows for operation of two or three state control accessors, either from the keyboard or programmable controller logic, provides logic to determine when a commandable device is operating normally or otherwise, allows selection of an English language descriptor, status code selection, reporting mode, operating mode selection and also provides an on-line diagostic for control accessors.

4.8 TREND LOG

Allows any 10 points to be logged on the data printer at a fixed time base.

4.9 HISTORICAL LOG

This provides a running log in the computers memory of up to 50 analogue devices.

4.10 SHIFT REPORT

Prints up to 64 analogues with their true arithmetic average value and also the highest and lowest value for that shift.

4.11 SHIFT REPORTS LONG TERM STORAGE

Automatically turns on the system disc and stores the daily shift report on disc. Previous reports can be retrieved.

4.12 DIAGNOSTICS

The Senturion 200 System has diagnostics for both hardware and software verification.

.1 Off-line diagnostics consist of PROM based confidence tests of the momory, CRT-terminal, real time clock event and data printer, PROMS, accessor trunk and interface, along with floppy disc drives and sub-system. Disc based diagnostics consist of memory tests, CPU - sub-system and floppy disc sub-system.

.2 On-line diagnostics consist of continuous on-line checking and reporting of problems on accessor trunks, continuous software checks along with a visual indication of the operation of trunk drivers and modem hardware.